Illinois Lake Michigan (nearshore) PCB TMDL Report

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LimnoTech

Water Environment | Scientists Engineers

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List of Acronyms

AOC	Area of Concern
AEOLOS	Atmospheric Exchange Over Lakes and Oceans Study
BAF	Bioaccumulation Factor
BMP	Best Management Practice
BSAF	Biota-Sediment Accumulation Factor
CAWS	Chicago Area Waterway System
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DL	Detection Level
FCMP	Fish Contaminant Monitoring Program
GIS	Geographic Information System
GLCFS	Great Lakes Coastal Forecasting System
GLI	Great Lakes Water Quality Initiative
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
HPV	Health Protection Value
IADN	Integrated Atmospheric Deposition Network
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
LA	Load Allocation
LaMP	Lakewide Management Plan
LMMBS	Lake Michigan Mass Balance Study
MDEQ	Michigan Department of Environmental Quality
MGD	Million Gallons per Day
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MWRD	Metropolitan Water Reclamation District of Greater Chicago
NPDES	National Pollutant Discharge Elimination system

NOAA	National Oceanic and Atmospheric Administration
OMC	Outboard Marine Company
ORD	Office of Research and Development
PCB	Polychlorinated Biphenyl
QAPP	Quality Assurance Project Plan
RF	Reduction Factor
TCE	Trichloroethene
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQS	Water Quality Standards
WCP	Waukegan Manufactured Gas and Coke Plant

Executive Summary

Polychlorinated biphenyls (PCBs) are a set of 209 synthetic chlorinated organic compounds (congeners) produced in the form of complex mixtures called Aroclors for industrial use in the United States from 1929 to the late 1970s. PCBs have been demonstrated to cause cancer, as well as a variety of other adverse health effects on the immune system, reproductive system, nervous system, and endocrine system (United States Environmental Protection Agency, USEPA, 2015). Although the commercial production of PCBs was banned in 1979, PCBs remain a concern due to their ability to persist in the environment and bioaccumulate in living tissues. Human exposure through the consumption of fish is the principal public health concern with PCBs in the environment.

PCB concentrations in Great Lakes top predator fish are declining, but PCB fish advisories remain in place for all five Great Lakes (USEPA, 2015a). This draft Total Maximum Daily Load (TMDL) report addresses PCB impairments in 56 waterbody segments located in the Illinois Lake Michigan nearshore. Appendix A lists specific waterbody segments covered by this TMDL.

The atmosphere is the primary source of PCB loads to the study area waterbodies, either via direct atmospheric input to these waterbodies or by transport into the study area from the main body of Lake Michigan (which is controlled by atmospheric sources). A TMDL has been developed to address PCB impairments in the nearshore Lake Michigan waterbodies. Based on a target fish tissue concentration of 0.06 mg/kg, which is generally considered safe for human consumption by Illinois Environmental Protection Agency (IEPA), this TMDL report sets a goal for reducing atmospheric PCB loading by 94.7 percent, relative to the baseline year of 2005.

Atmospheric deposition of PCBs in the study area comes from local, regional, national and global sources. Based on the assumption that fish PCB concentrations will respond proportionally to reductions in atmospheric PCB loadings, a TMDL and reduction goal was developed to meet the target fish tissue concentration of 0.06 mg/kg. Atmospheric PCB sources from Illinois must be reduced by 94.7% from 2005 levels to meet this goal (Table ES-1). Reductions are necessary from PCB sources within Illinois and in other U.S. states, and from global sources. However, this TMDL only addresses reductions from Illinois sources. Progress on achieving this goal in Illinois will be tracked through the analysis of PCBs in fish collected within the project study area.

Table ES-1. Summary of TMDL Components

TMDL Components	Results
Target Level and Reduction Factor	
Target Fish PCB Concentration (Fish Tissue Residue Value)	0.06 mg/kg
Baseline PCB Concentration for Carp	1.13 mg/kg
Reduction Factor	94.7 %
Final TMDL	
Loading Capacity (LC)	0.0026 kg/day
Necessary Reduction from Atmospheric Sources	94.7%
Margin of Safety (MOS)	Implicit
Wasteload Allocation (WLA)	0.000006 kg/day
Load Allocation (LA)	0.0026 kg/day
PCB Load Allocation for In-State and Out-of-State Deposition Sources	
In-State Contribution to LA [a]	0.0019 kg/day
Out-of-State Contribution to LA[b]	0.0007 kg/day

Numbers may not sum exactly due to rounding

[a] Calculated as 73% of LA

[b] Calculated as 27% of LA

1 Introduction

Section 303(d) of the Federal Clean Water Act and the USEPA's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations [CFR] Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for all category 5[1] waterbodies that are not meeting Water Quality Standards (WQS) for a specific pollutant. These waterbodies are included on a state's 303(d) list. The TMDL process establishes the allowable loadings of a pollutant to a waterbody based on the relationship between pollution sources and water quality conditions of a waterbody. This allowable loading represents the maximum quantity of a pollutant that the waterbody can receive without exceeding WQS. The TMDL process provides states with the basis for establishing water quality-based controls, which provide the pollutant reductions necessary for a waterbody to attain WQS (USEPA, 1991).

Within the Illinois Lake Michigan Basin, the Illinois Environmental Protection Agency (IEPA) has identified 56 nearshore beach/shoreline, harbor and open water segments that are impaired due to concentrations of PCBs in fish tissue and the water column (IEPA, 2014). All of these waterbody segments are impaired for fish consumption use, and one segment (Waukegan Harbor North) is also impaired for aquatic life use. These impaired waters are included on Illinois' Clean Water Act (CWA) Section 303(d) list (IEPA, 2014).

The scope of this TMDL covers the 56 nearshore beach/shoreline, harbor and open water segments impaired due to PCBs. It quantifies the pollutant load reductions needed to reduce PCB levels in fish tissue and the water column so that the waterbodies can meet WQS.

The report covers each step of the TMDL process and is organized as follows:

- Section 2. Background
- Section 3. Applicable WQS and TMDL targets
- Section 4. Source assessment
- Section 5. Modeling approach
- Section 6. TMDL development
- Section 7: Implementation plan and monitoring recommendations
- Section 8: Public participation

[1] Category 5 means available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

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2 Background

This section provides background information for PCB TMDL development. It is divided into the following sections:

- Problem statement
- Study area and impaired waterbodies
- Data compilation and assessment of water quality

2.1 Problem Statement

Polychlorinated biphenyls (PCBs) are a set of 209 synthetic chlorinated organic compounds (congeners) produced in the form of complex mixtures called Aroclors for industrial use in the United States from 1929 to the late 1970s. PCBs were used in insulation fluids in electrical transformers and generators, fluorescent lamp ballasts, caulk, and carbonless copy paper production. In 1979, USEPA banned commercial PCB production, but PCBs may be present in a wide range of products and materials produced before the 1979 ban, including electrical, heat transfer, and hydraulic equipment; plasticizers in paints, plastics, and rubber products; pigments, dyes, and carbonless copy paper; and many other industrial applications (USEPA, 2015). There are no known natural sources of PCBs. However, they continue to be produced inadvertently as a manufacturing byproduct of many chlorinated organic compounds.

PCBs have been demonstrated to cause cancer, as well as having a variety of other adverse health effects on the immune system, reproductive system, nervous system, and endocrine system. (USEPA, 2015). PCBs are relatively persistent and have a tendency to accumulate in sediments and concentrate and bioaccumulate in living tissues. Human exposure through the consumption of fish is the principal public health concern with PCBs in the environment.

2.1.1 Recent PCB Trends

Median PCB concentrations in top predators continue to decline since PCB production was banned; however, concentrations in all the Great Lakes remain above the 1987 Great Lakes Water Quality Agreement (GLWQA) target of 0.1 mg/kg wet weight (USEPA, 2012). A log-linear regression of USEPA data shows 6-percent annual declines in total PCB in lake trout from Lake Michigan (USEPA, 2012; Figure 2-1).

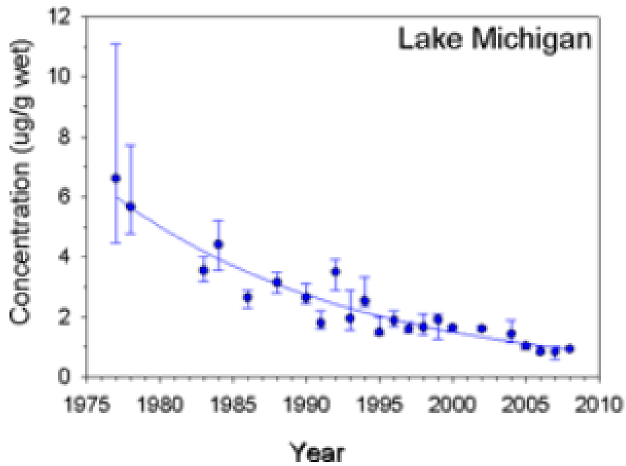


Figure 2-1. Total PCB (Median and Inter-Quartile Range) Concentrations for Composited Lake Michigan Whole Body Lake Trout (adapted from McGoldrick et al., 2012 as presented in USEPA, 2012)

The Integrated Atmospheric Deposition Network (IADN), created in 1990, is a joint venture of Environment Canada, the Ontario Ministry of the Environment, and the USEPA's Great Lakes National Program Office. IADN consists of a master monitoring station located on each of the five Great Lakes and several satellite stations, including one in Chicago. One of the goals of IADN is to determine whether the concentrations of toxic organic compounds in air and precipitation near the Great Lakes are changing as a function of time. Total gas phase concentrations of PCBs measured by IADN show a general decrease between 1992 and 2002 (USEPA, 2015b; Figure 2-2). The rate of decline for the Lake Michigan IADN site at Sleeping Bear Dunes, Michigan(1991-1997) and the IADN site at Chicago (1997-2003) is approximately 7 percent per year (Sun et al., 2006), which is similar to the rate of decline in Lake Michigan lake trout (Figure 2-1).

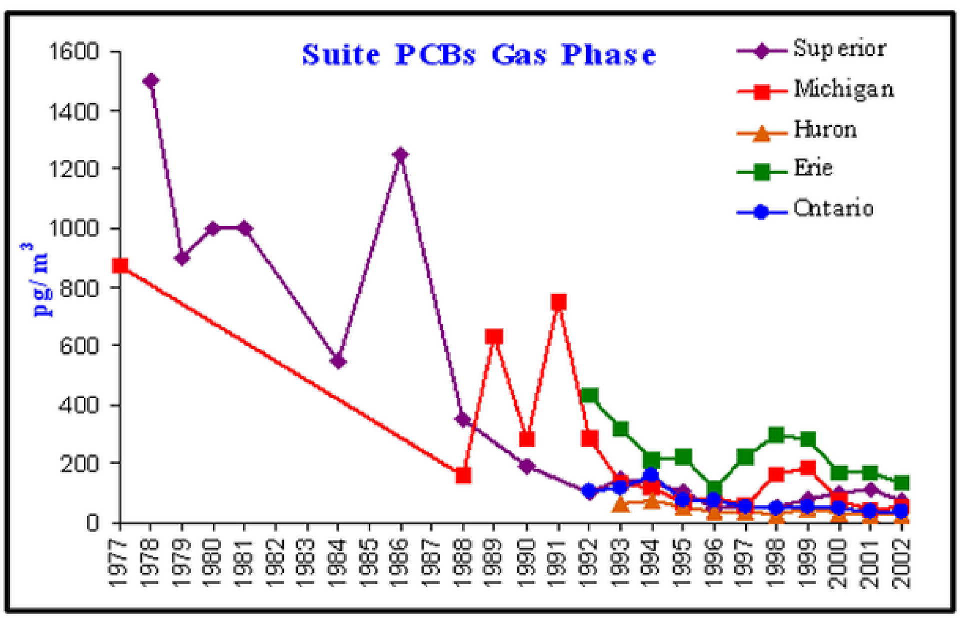
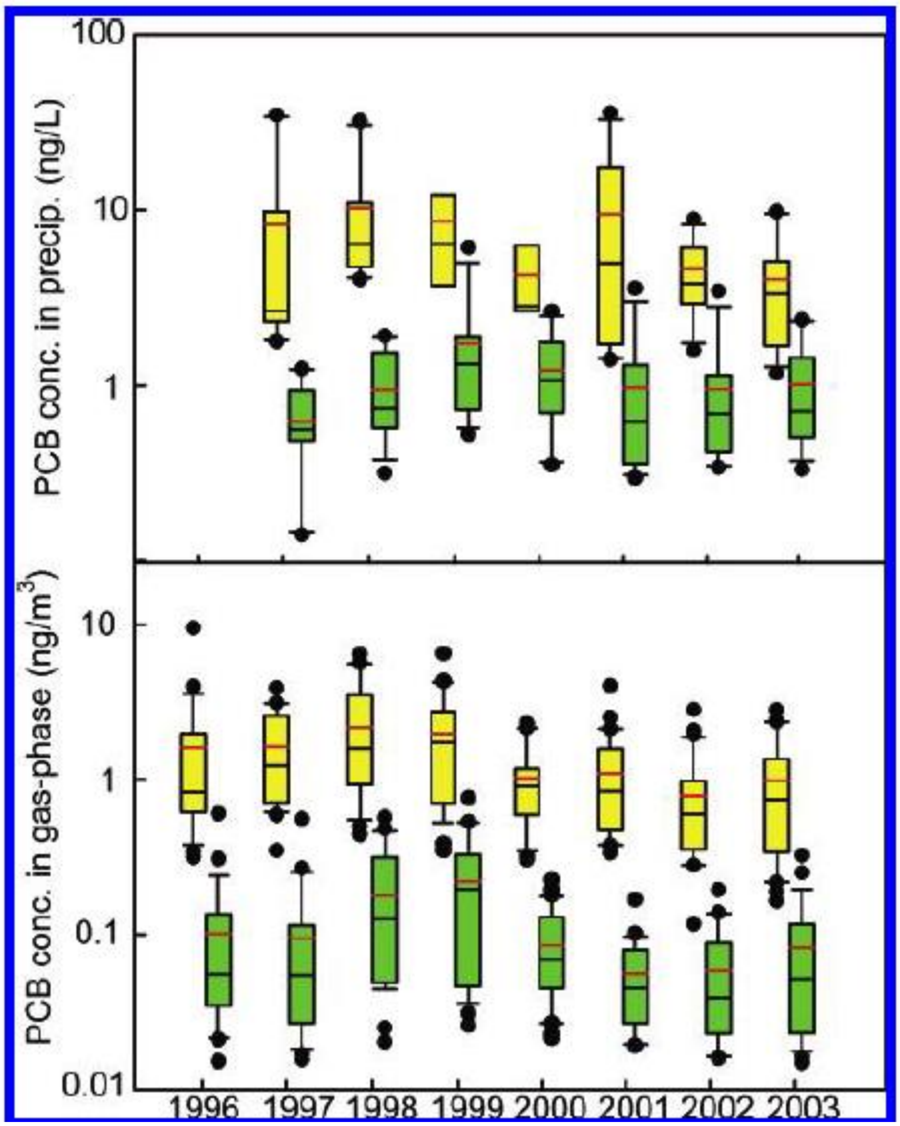


Figure 2-2. Time Trend of PCB Gas Phase Atmospheric Concentrations at Great Lakes IADN Stations (Source: USEPA, 2015b)

Gas phase PCB concentrations in Chicago have decreased by about half between 1996 and 2003. However, the atmospheric gas phase PCB concentrations observed over Chicago continue to be much higher than concentrations measured over the main Lake Michigan open water and at other IADN stations (Buehler and Hites, 2002). Total PCB concentrations in precipitation and gas phase over Chicago are about an order-of-magnitude higher than over Sleeping Bear Dunes (Figure 2-3). Studies during the Lake Michigan Mass Balance Study (LMMBS; Green et al., 2000) and the Atmospheric Exchange Over Lakes and Oceans Study (AEOLOS, Simcik et al., 1997; Zhang et al., 1999) confirmed that a combination of prevailing westerly winds off Chicago and an elevated rate of PCB gas phase emissions over the city led to elevated gas phase PCB concentrations for about 20-40 km off the Chicago shoreline. These elevated gas phase PCB concentrations consequently lead to increased absorption fluxes, i.e. the transfer of gas phase PCBs from the atmosphere to the water column.



The horizontal lines represent the 10th, 50th, and 90th percentiles; the red lines are the means; the boxes represent the 25th to 75th percentiles; outliers are shown individually

Figure 2-3. Total PCB Concentrations in Precipitation (top) and Atmospheric Gas Phase (bottom) for Chicago (yellow) and Sleeping Bear Dunes (green) IADN Master Stations (from Sun et al., 2006)

2.2 Study Area and Impaired Waterbodies

The project study area, shown in Figure 2-4, includes one nearshore open water segment, 51 beach/shoreline segments, and four harbors that are identified by IEPA (IEPA, 2014) as being impaired due to PCBs. All 56 impaired water segments are in Lake and Cook Counties, Illinois. The fish consumption use is *Not Supporting* for all segments, and the aquatic life use is also *Not Supporting* for Waukegan Harbor North. Appendix A contains a complete list of the impaired segments and causes.

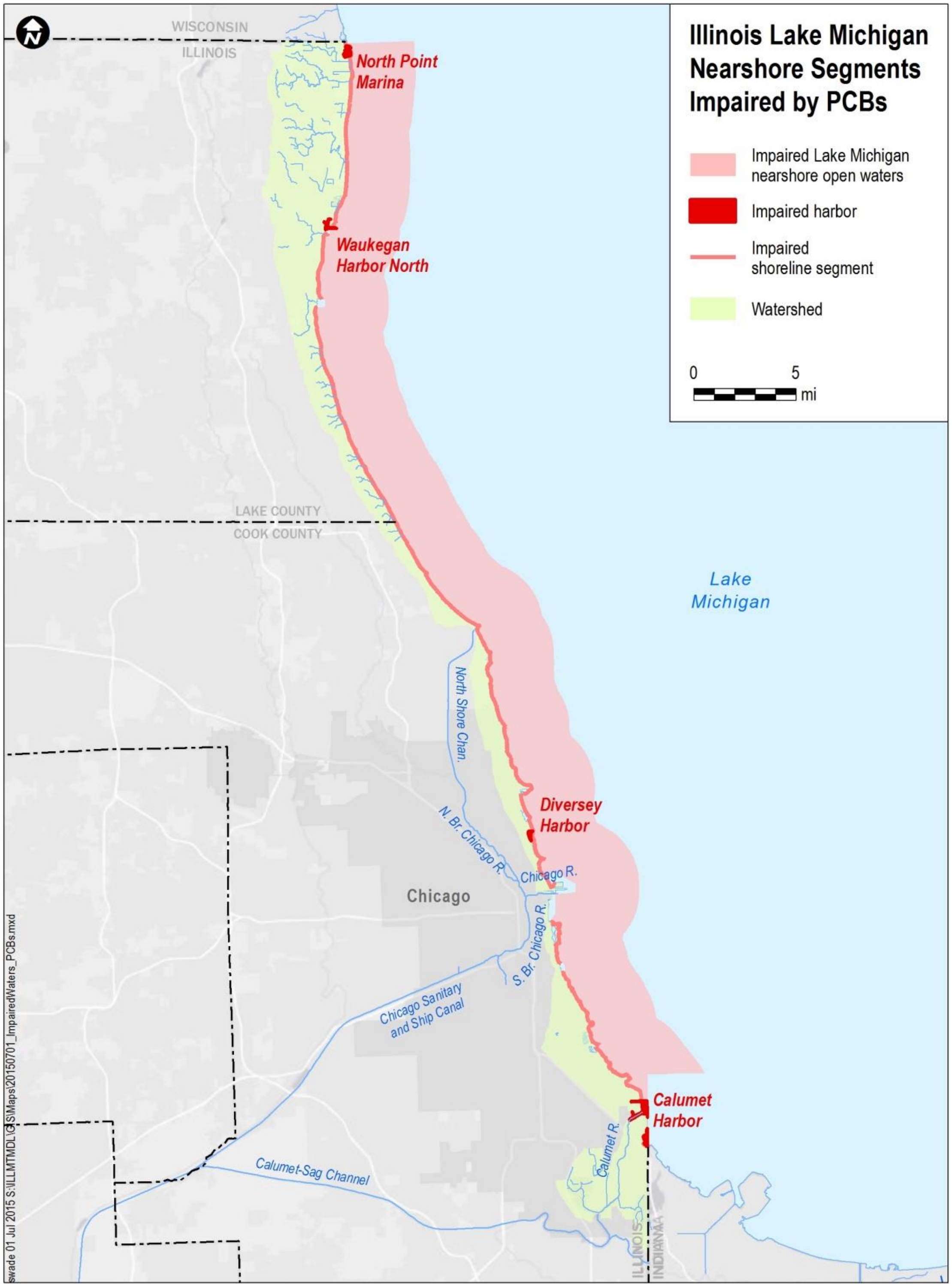


Figure 2-4. Project Study Area and Impaired Segments

2.2.1 Watershed Description

The study area watershed is long and narrow and encompasses roughly 100 square miles within Lake and Cook Counties, Illinois, that drain to Lake Michigan. The study area watershed is highly developed, and land use is roughly distributed as 73 percent residential, 4 percent industrial, 4 percent commercial, and 19 percent open space. The watershed includes portions of the following municipalities: Wilmette, Winnetka, Kenilworth, Winthrop Harbor, Chicago, Burnham, Highland Park, Lake Bluff, Beach Park, Highwood, Waukegan, North Chicago, Zion, Evanston, Glencoe, and Lake Forest. All of the listed municipalities except Burnham have Municipal Separate Storm Sewer System (MS4) permits to discharge to Lake Michigan. The MS4 permits for these municipalities, together with the MS4 permits for the Cook County Highway Department, Lake County, Shields Township, and Waukegan Township (permit numbers presented in Table 6-2), cover roughly 100 percent of this drainage. Although a number of permitted point sources are located in the watershed, only one (Zion Station) was considered to have the potential to discharge PCBs to the impaired waters (Figure 2-5), due to the PCB monitoring requirement in its National Pollutant Discharge Elimination System (NPDES) permit (Permit ID IL0002763).

The waterbodies within the watershed are generally small streams and ravines that carry intermittent stormwater and surface drainage to Lake Michigan. Within Lake County, the watershed boundary extends inland farther than it does in Cook County, narrowing near the south end of Lake County due to the diversion of flows into the Chicago Area Waterway System (CAWS). The CAWS is heavily altered from its natural state, including a diversion of the Chicago River (in 1900), and the Little and Grand Calumet River (in 1922) away from Lake Michigan via the CAWS. The CAWS is a major component of the study area, comprising both manmade and natural waterways. In addition to navigation, these waterways convey a variety of point-source and precipitation-related flows, including water reclamation plant effluents, combined sewer overflows (CSOs), and stormwater runoff. While the direction of flow in the CAWS is typically toward the Des Plaines River watershed and away from the study area waterbodies, extreme wet weather conditions can create storm flows large enough to cause flow reversals in the CAWS and discharge into Lake Michigan. These discharges occur via three control works locations: the Wilmette Pumping Station, the Chicago River Lock and Controlling Works, and the O'Brien Lock and Controlling Works on the Calumet River (Figure 2-5). These discharges from the CAWS to Lake Michigan are of interest because PCBs in stormwater and CSO, which discharge into the CAWS, can contribute to the impairment of the Lake Michigan study area waters.

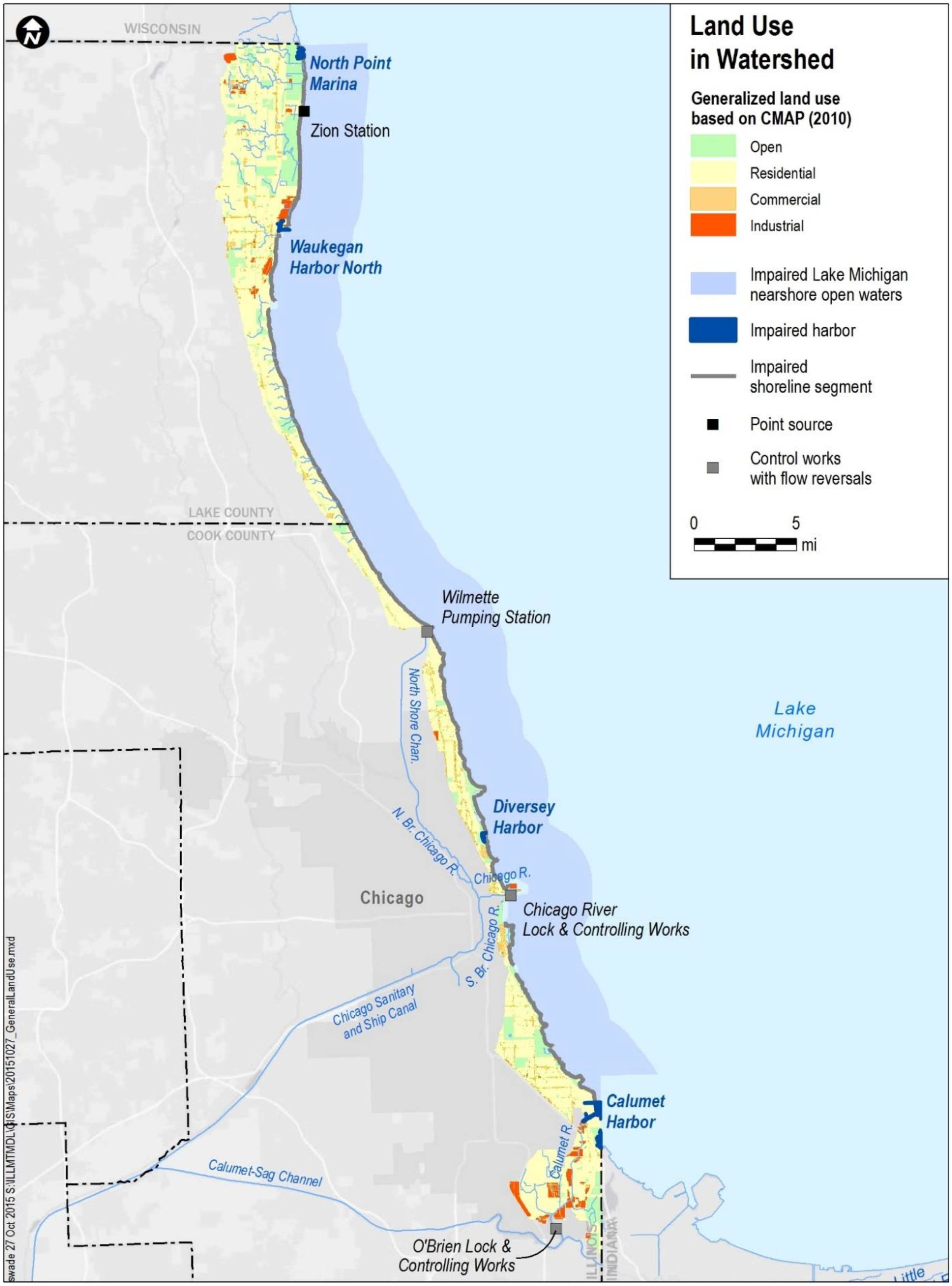


Figure 2-5. Study Area Land Use

2.2.2 Impaired Waterbody Description

A total of 56 segments are impaired due to PCBs. The impaired nearshore open water segment is 180 square miles in size, extending 5 km into Lake Michigan from the Illinois shoreline, with Lake Michigan serving as its eastern boundary (Figure 2-5). Additionally, 51 shoreline (beach) segments have been identified as impaired due to PCBs. The term *shoreline segment* is used in this document, because not all of the segments have beaches. The total length of these shoreline segments is approximately 63.5 miles, with segment lengths ranging from 0.07 to 5.5 miles.

Interspersed with the shoreline segments are four harbors that are impaired due to PCBs: Waukegan Harbor North (~0.07 square miles), North Point Marina (~0.12 square miles), Diversey Harbor (~0.05 square miles), and Calumet Harbor (~2.4 square miles). These harbors, shown in Figure 2-6, are described briefly below.

Waukegan Harbor, a federally authorized navigation project in Waukegan, Illinois. is used for both industrial and recreational activities (IDNR, 2012). This manmade harbor is approximately 40 miles north of the city of Chicago. The United States Army Corps of Engineers (USACE) has been involved with dredging operations at this harbor since 1889. With the exception of some intermittent harbor deepening projects, the vast majority of the dredging operations have focused on maintaining navigable conditions, primarily within the approach channel (Department of the Army, Chicago District, Corps of Engineers, 2013), which is beyond the extent of the impaired area shown in Figure 2-5. In 1975, PCBs were discovered in Waukegan Harbor sediments. An estimated 300,000 pounds of PCBs were discharged into the harbor by Outboard Marine Corporation (OMC) between 1961 and 1972. The site was added to the National Priorities List in the early 1980s, and in 1981, the United States and Canadian governments identified Waukegan Harbor as an Area of Concern (AOC). In 1992 and 1993, roughly one million pounds of PCBs were removed during remediation activities at the Outboard Marine Corporation site and Waukegan Harbor, including the removal of 32,000 cubic yards of contaminated sediments from the Waukegan Harbor AOC (USEPA, 2015c). In 2002, USEPA and IEPA determined, through risk assessment, the remediation standards for PCB concentrations that would meet the ecological target of lowering the levels of PCB concentration in sport fish tissue to levels seen in open lake sport fish. The resulting target for PCB concentrations in sediment were 0.25 to 1.0 ppm (IDNR, 2012). In 2012 and 2013, an additional 124,000 cubic yards of contaminated sediment were removed from Waukegan Harbor (USEPA, 2015c). The Waukegan Harbor Area of Concern Habitat Management Plan (IDNR, 2012) defines the PCB target for Waukegan Harbor open water unit as “reduce PC B levels in Waukegan Harbor sediments to 0.2 ppm.”

North Point Marina, in Winthrop Harbor, Illinois, is the largest marina on the Great Lakes (IDNR, 2015a). **Diversey Harbor** is in Lincoln Park, within Lake Shore Drive. Due to bridge restrictions, Diversey Harbor can only accommodate power boaters (Chicago Harbors, 2015).

Calumet Harbor and the Calumet River include an approach channel, an outer harbor channel, an entrance channel, and a river channel. The approach and outer harbor channels are located primarily in Indiana. The entrance channel and river channel are located in Illinois and extend approximately 6.7 miles up the Calumet River to Lake Calumet (USACE Chicago and Rock Island Districts, 2015). Calumet Harbor is a deep draft commercial harbor that is protected by 12,153 linear feet of steel sheetpile and timber crib breakwater structures (USACE Detroit District, 2015). This is the largest of the study area’s four impaired harbors, and Calumet Harbor and River are the third busiest port on the Great Lakes by tonnage, moving an annual average of over 14 million tons of commodities (USACE Detroit District, 2015). At Calumet Harbor and River, an average of approximately 50,000 cubic yards of sediment are dredged annually, and this dredging requirement is expected to continue (USACE Chicago and Rock Island Districts, 2015).

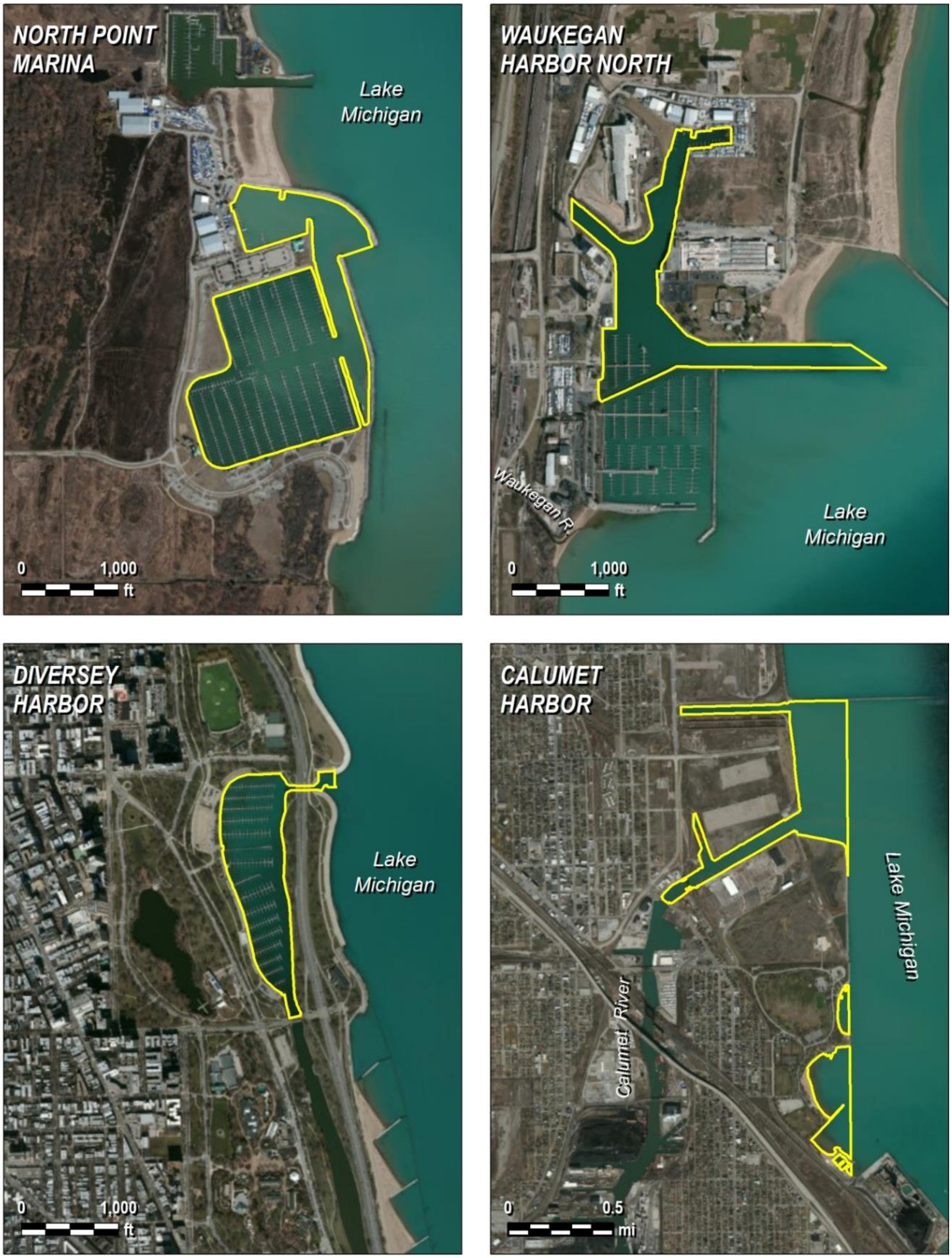


Figure 2-6. Impaired Harbor Segments

2.3 Data Compilation and Assessment of Water Quality

Water column, fish, and sediment data collected from 2000 to the present were inventoried, compiled, and reviewed to form the project database for the PCB TMDL. Data were reviewed to ensure they were relevant to the project and met the quality objectives and criteria outlined in the project's Quality Assurance Project Plan (QAPP).

The potentially useful sources of data were identified based on project team knowledge, including much input from IEPA and USEPA staff, internet queries, and communication with agencies and Great Lakes researchers familiar with the project study area. In addition, the project team led a webcast on September 17, 2014, to present the objectives of the study to a much broader audience and to solicit input on additional studies or data sets that could be relevant to this project. The project team followed up on all leads identified as a result of the webcast.

Agencies contacted for data included the USEPA Great Lakes National Program Office (GLNPO); USEPA Office of Research and Development (ORD), Grosse Ile, Michigan; USEPA Superfund Division; USEPA Water Division; IEPA Toxicity Assessment Unit, IEPA Bureau of Water; Illinois Fish Contaminant Monitoring Program (FCMP); Illinois Department of Natural Resources; Wisconsin Water Science Center of the U.S. Geological Survey (USGS); National Oceanic and Atmospheric Administration (NOAA); Environment Canada; Area of Concern project managers; USACE; U.S. Navy; Waukegan Citizens Advisory Group; North Shore Sanitary District; Illinois Lake Michigan Fisheries Program; and researchers at Loyola University and the University of Iowa.

2.3.1 Summary of Data by TMDL Zone

The project database contains fish tissue, water column, and sediment data. Fish fillet data are summarized in this section because those are the samples used to support the TMDL.

Sampling locations for all water column, fish, and sediment data in the database were paired with impaired waterbody segment(s), with input from IEPA, reflecting which sampling stations were located within the impaired segments. IEPA assessed use support for the nearshore open water segment based on samples collected in the nearshore open water segment. The 51 shoreline segments were similarly assessed based on samples collected in the nearshore open water segments. Because the data collected in the nearshore open water were used to assess the nearshore as well as the 51 shoreline segments, these segments are collectively referred to as being within the "nearshore open water/shoreline" TMDL Zone. Samples collected within each of the four impaired harbors (Calumet, Diversey, North Point Marina, and Waukegan North) were assigned to the appropriate harbor. Fish samples collected just outside the nearshore open water segment were also categorized as "nearshore open water/shoreline," due to fish mobility. Samples collected from Lake Michigan well outside the nearshore open water segment were classified as "offshore."

The tables that follow summarize the number of samples available in the project database for the study area. A count of PCB fillet samples, by fish species and TMDL zone, is shown in **Error! Reference source not found.**. Note that 109 of the 164 samples are composites, with the number of fish per composited sample ranging from 2 to 25. Table 2-2. presents a count of water column and sediment PCB samples by TMDL zone. The location of the PCB fish fillet samples is shown in Figure 2-7.

Table 2-1. Count of Fish PCB Fillet Samples by Species and TMDL Zone

Fish Species	TMDL Zone					Grand Total
	Nearshore open water/ shoreline	Calumet Harbor	Diversey Harbor	North Point Marina	Waukegan Harbor	
Alewife	6	-	-	-	-	6
Black bullhead	-	-	-	-	3	3
Bloater chub	7	-	-	-	-	7
Brown trout	1	-	-	-	-	1
Carp	-	-	-	12	40	52
Lake trout	30	-	-	-	-	30
Largemouth bass	-	-	-	3	1	4
Pumpkinseed sunfish	-	-	1	-	2	3
Rainbow smelt	1	-	-	-	-	1
Rainbow trout	2	-	-	-	-	2
Rock bass	-	1	-	4	5	10
Round goby	-	1	-	2	-	3
Smallmouth bass	-	5	-	2	-	7
Sunfish	-	-	-	4	3	7
White sucker	-	-	-	2	4	6
Yellow perch	21	-	-	-	1	22
Grand Total	68	7	1	29	59	164

Table 2-2. Count of PCB Water Column and Sediment Samples by TMDL Zone

Media	TMDL Zone				Grand Total
	Nearshore open water/ shoreline	Calumet Harbor	North Point Marina	Waukegan Harbor	
Water column	All 110 measurements <DL[a]	-	-	-	110
Sediment	8[b]	6[c]	2	4	20

[a]The detection level (DL) for 110 IEPA nearshore water column PCBs ranged from 0.04 to 0.55 ug/l

[b]Collected from Waukegan Approach Channel

[c]These 6 sediment samples were collected from material on the dredging barge; the exact location is not known.

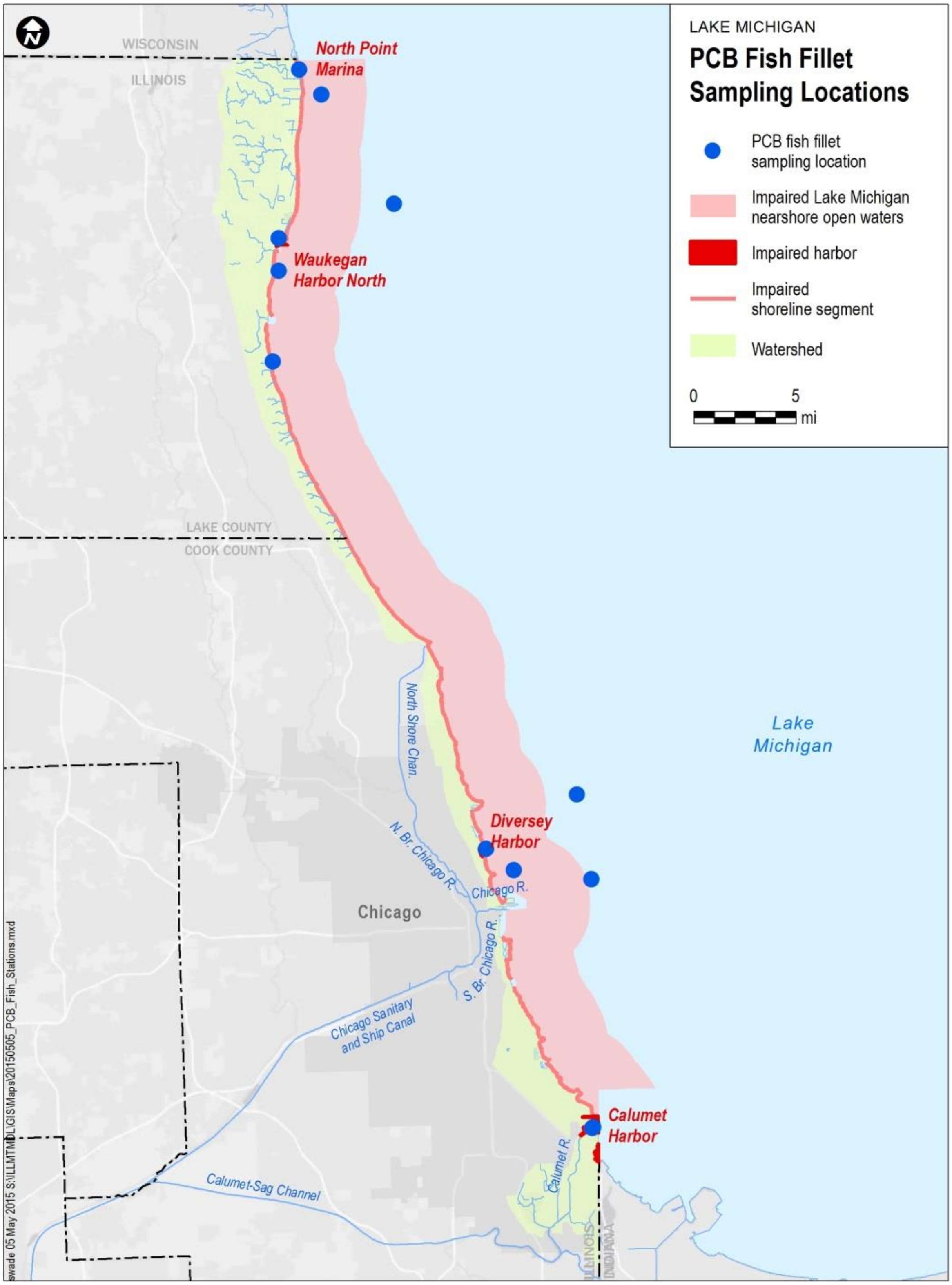


Figure 2-7. Sampling Locations for PCB Fish Fillets

3 Applicable Water Quality Standards and TMDL Targets

This section describes relevant WQS, designated use support, and numeric TMDL targets for PCBs.

3.1 Water Quality Standards

The Clean Water Act, Section 303(c)(2)(A), requires states to designate appropriate water uses for all waterbodies, and adopt WQS for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. Designated uses describe the various uses of waters that are considered desirable, and identify those waters that should be protected. Some examples of designated uses are primary contact (such as swimming and water skiing), fish consumption, aquatic life, and aesthetic quality. Surface waters in Illinois fall into one of four categories: General Use, Public and Food Processing Water Supplies, Secondary Contact and Indigenous Aquatic Life, and Lake Michigan Basin (IEPA, 2014). Each category has its own set of WQS. The standards for the Lake Michigan Basin are found in the Illinois Administrative Code (35 IAC 302.501-595, Subpart E). Some of the Lake Michigan Basin WQS apply to all waters within the basin, while others apply only to the open waters of the Lake or only to tributary waters of the Lake. WQS for the Lake Michigan Basin protect aquatic life, human health, wildlife, and recreational uses. Waters of the Lake Michigan Basin must be free from any substance or any combination of substances in concentrations toxic or harmful to human health or to animal, plant, or aquatic life (35 IAC 302.540). Lake Michigan Basin waters include all tributaries of Lake Michigan, harbors, and open waters of the Illinois portion of the lake. Numeric water quality criteria are developed to protect the designated uses of surface waters, and the standards for PCBs are described below.

The WQS for PCBs in surface waters of the Lake Michigan basin are 120 pg/L for the protection of wildlife, and 26 pg/L for the protection of human health [35 IAC 302.504(e)]. The PCB standard applies to all waters of the Lake Michigan Basin. These standards were adopted by the State of Illinois as part of the Great Lakes Water Quality Initiative (GLI).

3.2 Designated Use Support

Every two years, the State of Illinois evaluates the extent to which waters of the state are attaining their designated uses. The degree of support of a designated use in a particular area (assessment unit) is determined by an analysis of biological, physiochemical, physical habitat, toxicity, and other data. When sufficient data are available, each applicable designated use in each assessment unit is assessed as *Fully Supporting* (good), *Not Supporting* (fair), or *Not Supporting* (poor). Waters in which at least one applicable use is not fully supported are considered impaired.

Fish consumption use is associated with all waterbodies in the state. The assessment of fish consumption use is based on (1) waterbody-specific fish-tissue data and (2) fish-consumption advisories issued by the multi-agency[2] Illinois FCMP, which consists of staff from the departments of Agriculture, Natural Resources, Public Health, the Illinois Emergency Management Agency, and the IEPA. The FCMP uses a risk-based process developed in the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (Anderson et al. 1993). The Protocol requires the determination of a Health Protection Value (HPV) for a contaminant, which is then used to calculate the level of contaminant in fish tissue that will be protective of human health at several meal consumption frequencies (ranging from unlimited consumption to "do not eat"). This information is used to calculate the level of the contaminant in fish that will not result in exceeding the HPV at each meal consumption frequency.

For PCBs, the HPV for fish consumption is 0.05 µg/kg/day. Based on this HPV, the lowest fish tissue concentration that results in a fish consumption advisory is 0.06 mg/kg for all species; this is, therefore, the concentration used to assess support of the fish consumption use. It should be noted that this fish tissue assessment concentration was derived independently of numeric water column criteria.

Except in extraordinary circumstances, two or more recent sampling events in a waterbody in two different sampling years finding fish exceeding the fish tissue level of concern are necessary for issuing an advisory (based on data collected since 1985). The issuance of a fish-consumption advisory for a specific waterbody provides the basis for a determination that fish consumption use is impaired, with the contaminant of concern listed as a cause of impairment.

Aquatic life uses are assessed using available data for the most recent three years. For Lake Michigan open waters and harbors, if two or more samples exceed the acute aquatic life criterion, the waters are considered impaired. If more than 10 percent of the samples exceed the chronic aquatic life criterion, the waters are considered impaired.

3.3 Numeric TMDL Targets

TMDL targets are established at a level that attains and maintains the applicable WQS, including designated uses, numeric and narrative criteria, and antidegradation policy [40 CFR §130.7(c)(1)]. TMDL submittals must include a description of any applicable water quality standard, and must also identify numeric water quality targets, which are quantitative values used to measure whether or not applicable WQS are being attained. Depending on the designated use being addressed, a TMDL target may be based on human health, aquatic life, or wildlife criteria (USEPA, 2011). Where possible, the water quality criterion for the pollutant causing impairment is used as the numeric water quality target when developing the TMDL. Because all of the assessment units addressed in this TMDL are impaired for the fish consumption use, the HPV for fish consumption for sensitive populations was used to derive the TMDL target. The TMDL target is the PCB fish tissue concentration of 0.06 mg/kg.

[2] From Illinois Department of Public Health website Factsheet "Fish Advisories in Illinois"

4
Source Assessment

The purpose of a source assessment is to consider all potential sources of the pollutant of concern, in order to quantify source reductions that are needed to attain designated uses. The sources that were investigated and their estimated load contributions are discussed in this section.

Because this TMDL is based on an approach that groups all segments (discussed in more detail in Section 5), the total load to the study area (rather than to each impaired waterbody segment) is presented. The following source categories were investigated:

- Hydrodynamic transport
- Atmospheric loading
- MS4 stormwater loading
- Flow reversals from the Chicago Area Waterways
- Other point source discharges
- Resuspension and/or pore water diffusion of PCBs from bed sediments

As described below, the most significant sources were found to be hydrodynamic transport of PCBs from the open water of Lake Michigan and atmospheric loading. Resuspension and/or pore water diffusion of PCBs from bed sediments were found to be insignificant contributors. The remaining source categories, while smaller than hydrodynamic transport and atmospheric loading, could only be roughly estimated, because all available data for those sources were below laboratory detection limits.

4.1 Hydrodynamic Transport

The open water of Lake Michigan is a source of PCBs to the project study area. As described below, the predominant flow patterns in Lake Michigan circulate counter-clockwise in the vicinity of the study area (Beletsky and Schwab, 2001; Beletsky et al. 1999). As such, PCB loads to the study area can be estimated using the flow into the study area and Lake Michigan PCB concentrations at the northern end of the study area.

Hydrodynamic transport between Lake Michigan and the nearshore open water segment was estimated for this project using the NOAA Great Lakes Coastal Forecasting System (GLCFS). The GLCFS is a set of models that simulate and predict the two- and three-dimensional structure of currents, temperatures, winds, waves, and ice in the Great Lakes using a 4-km^2 (2 km x 2 km) grid size. The GLCFS uses a modified Princeton Ocean Model, developed by NOAA's Great Lakes Environmental Research Laboratory and The Ohio State University, which is supported by the National Weather Service (NOAA, 2015).

To estimate the gross transfer of PCBs into the study area, results from the GLCFS were used to estimate the annual average flow of Lake Michigan water into the study area. GLCFS modeling results were extracted for the northern edge of the study area, as this is the entry point based on the lake current's predominant flow direction. Figure 4-1 shows the mean circulation adapted from Beletsky and Schwab

(2001). The mean current velocity from the north was 3.35 cm/s for 2014. The area of transfer between the open lake and the study area was calculated as 54,000 m^2 by multiplying the average depth of the first two model grid cells from the GLCFS (10 m and 17 m) by the width of each cell (2 km each). Multiplying the average speed by the area produced an average flow into the study area of 1,810 m^3/s. Results from the USEPA Great Lakes Aquatic Contamination Survey data estimated the open lake PCB concentration in Lake Michigan as approximately 0.140 pg/L in 2004. Venier et al. (2014) reported Lake Michigan PCB concentrations near Chicago of 233 pg/L. Multiplying this range of concentrations by the flow equaled 8-13 kg/yr of PCBs entering the study area due to transport from Lake Michigan. The Lake Michigan Mass Balance Study estimated that by 2014, the average lake-wide PCB concentration could be as low as 80 pg/L if the "continued slow recovery" scenario (representing a lower-bound estimate in the rate of decrease in atmospheric PCB concentrations) is followed, as shown in Figure 4-2. This could reduce the annual PCB load entering the study area from 8-13 kg/yr to 4.6 kg/yr.

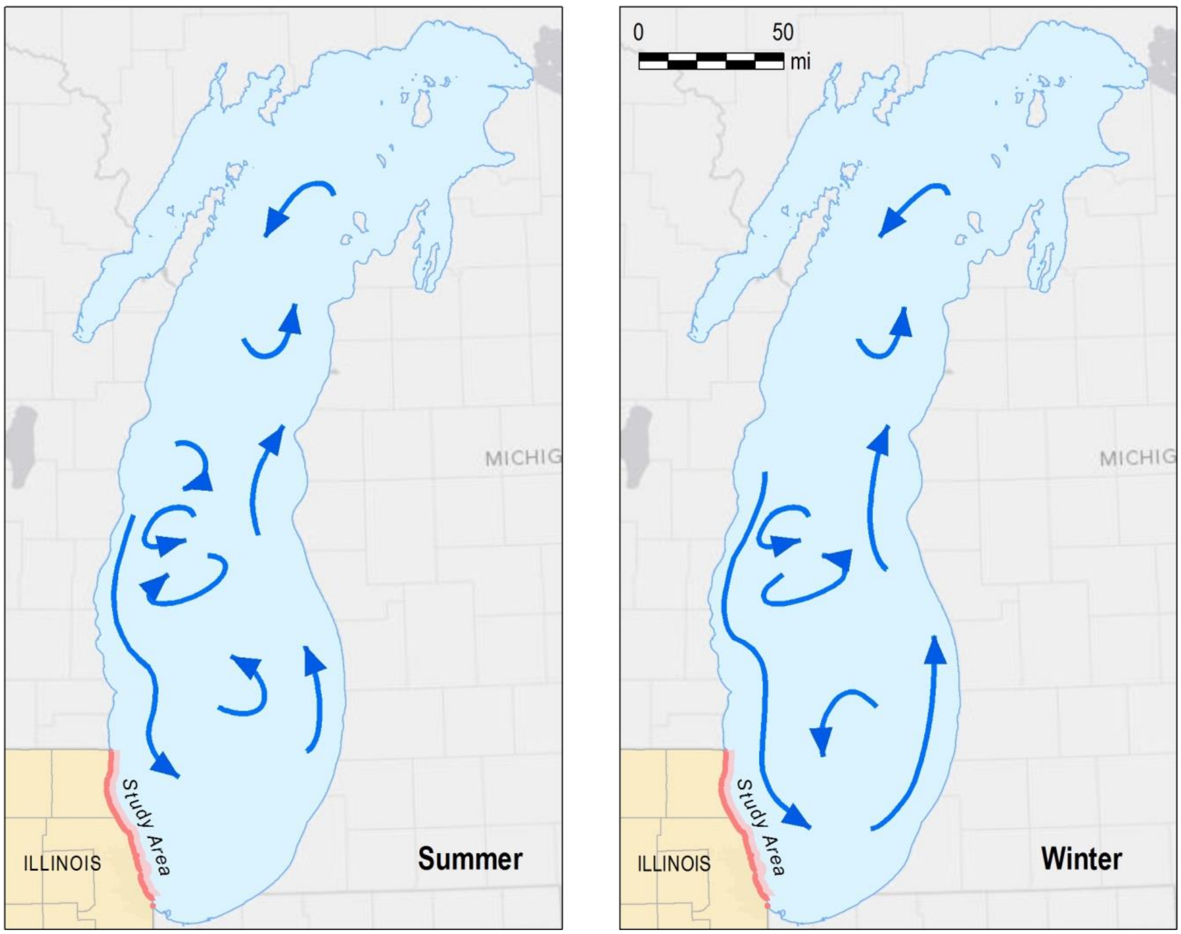


Figure 4-1. Observed Mean Circulation in Lake Michigan (Adapted from Beletsky et al., 1999 cited in Beletsky and Schwab, 2001)

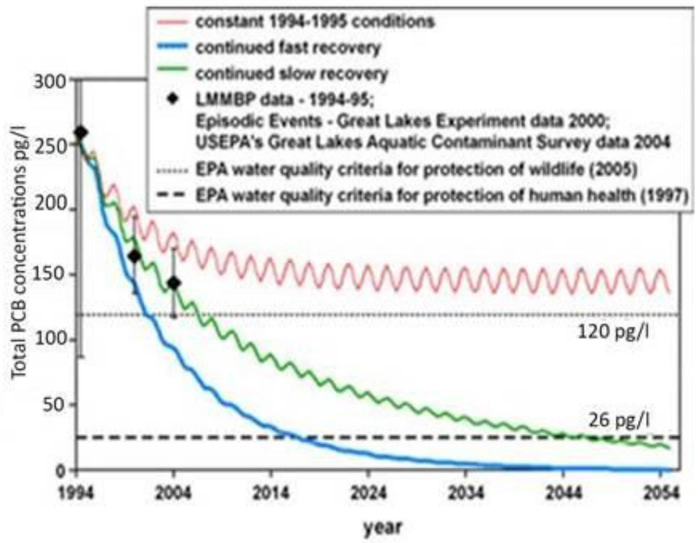


Figure 4-2. Lake Michigan Mass Balance Monitoring Data and Model Results

http://www.epa.gov/med/grosseile_site/LMMBP/pcbs.html

4.2 Atmospheric PCB Loading

PCBs can be delivered to the study area from atmospheric sources via three mechanisms: wet deposition, dry deposition, and gas deposition. Wet deposition consists of PCBs contained in precipitation. Dry deposition consists of PCBs attached to airborne particulates that settle onto the lake. Gas deposition occurs as a transfer across the air-water interface when atmospheric gas phase PCB concentrations exceed the equivalent dissolved phase PCB concentrations in the water column. Miller et al. (2001) demonstrated that gas deposition in the Chicago area of Lake Michigan greatly exceeds wet and dry deposition, so the calculations that follow focus solely on gas deposition as the dominant component of atmospheric PCB loading.

The magnitude of gas deposition is determined by two primary factors: the atmospheric gas phase PCB concentration, and the mass transfer coefficients that control the rate at which PCB concentrations pass through the air-water interface. The methods used to estimate these parameters are discussed below, followed by a presentation of the estimated loading rate.

4.2.1 Atmospheric Gas Phase PCB Concentration

Two primary data sets exist to describe atmospheric PCB concentrations in the vicinity of the study area:

1. The Integrated Atmospheric Deposition Network (IADN), established in 1990 to monitor PCBs in the air around the Great Lakes.
2. The Atmospheric Exchange Over Lakes and Oceans Study (AEOLOS), designed to assess atmospheric depositional fluxes of pollutants to large waterbodies, originating from urban coastal areas.

PCB monitoring from both of these studies show that instantaneous PCB concentrations over Lake Michigan near Chicago vary drastically as a function of wind direction and season. Wind direction was important, due to the fact that off-shore winds transported the high atmospheric concentrations of PCBs originating in Chicago over the lake (e.g. Simcik et al., 1997). Atmospheric PCB concentrations were also strongly correlated to air temperature, as warmer temperatures led to increased volatilization of land-based PCBs to the atmosphere. Because of the large day-to-day variation in atmospheric PCB concentrations in response to environmental conditions, estimation of annual average concentrations requires that discrete concentration measurements somehow be integrated over the range of environmental conditions.

Zhang et al. (1999) and Venier and Hites (2010a) both provided empirical regressions that estimate atmospheric PCB concentration as a function of environmental conditions. Zhang et al. (1999) applied their regression over the range of 1994-1995 environmental conditions to predict an annual average atmospheric PCB concentration of 356 pg/m^3 for the southern quarter of Lake Michigan. The regression of Venier and Hites (2010a), which applies to the entire Great Lakes region, includes independent variables of date and local population.

The alternative to empirical regressions for estimating annual average PCB concentrations is to take an average of multiple discrete measurements that represent a full spectrum of wind and temperature conditions. Simcik et al. (1997) provide such a data set, with 25 nearshore over-lake PCB measurements from 1994 to 1995, covering three seasons and a range of wind directions. The average of these data is 529 pg/m^3, compared to the 356 pg/m^3 reported by Zhang et al. (1999) for the same time period. This difference in results seems reasonable, as:

- The Simcik et al. (1997) data were specific to the Illinois nearshore area.
- The Zhang et al. (1999) calculation represented the average over the southern quarter of Lake Michigan.
- The Chicago area has been identified as a significant source of atmospheric PCBs to Lake Michigan (Sun et al., 2006), such that atmospheric concentrations in the Chicago nearshore area would be greater than the average concentration over the southern quarter of Lake Michigan.

4.2.2 Mass Transfer Rate at the Air-Water Interface

The magnitude of gas deposition also depends upon the rate of mass transfer of PCBs through the air-water interface. Zhang et al. (1999) demonstrated that this rate depends upon wind and water temperature, and calculated the spectrum of mass transfer rates that occurred in response to hourly wind speed and water temperatures from buoy data. The results of their analysis showed an annual gross absorptive flux of PCBs of 300 kg/yr in response to an annual average PCB concentration as 356 pg/m^3. Their flux calculation represented the 16,000 km^2 surface area of southern Lake Michigan. Therefore, normalizing their calculation on an areal basis results in an annual mass transfer rate of 300 kg/yr per 356 pg/m^3 per 16,000 km^2 = 5.3 x 10^{-5} kg/km^2/yr / (pg/m^3). The next section describes the combination of this mass transfer rate with the atmospheric PCB concentration and surface area of the study area waterbodies to calculate a PCB loading rate from atmospheric sources.

4.2.3 Atmospheric Loading Rate

To calculate the atmospheric loading rate, an atmospheric gas phase concentration was selected and merged with information on the mass transfer rate. Section 4.2.1 presented a range of methods for estimating the annual average atmospheric PCB concentrations over the study area. The results from Simcik et al. (1997) are recommended to serve as the basis of this estimate, as they provide the only estimate of concentrations based solely on data specific to the study area. The results from Zhang et al. (1999) correspond to the entire southern portion of Lake Michigan, while the work of Venier and Hites is more regionally-based, covering the entire Great Lakes. These results were therefore less applicable to this TMDL study.

The data from Simcik et al. (1997) showed an annual average atmospheric PCB concentration over the study area of 529 pg/m^3 for the period of 1994-1995. Atmospheric PCB concentrations throughout the Great Lakes in general, and over the Chicago area in particular, have been observed to decrease over that period. Sun et al. (2006) calculated a half-life of atmospheric PCB concentration in the Chicago area of 7.7 years, while Venier and Hites (2010b) calculated that atmospheric PCBs around the Great Lakes were decreasing with a half-life of 17 years. The estimated 2015 PCB concentration ranges from 87 to 234 pg/m^3, depending upon which decay rate is assumed.

Combined with the mass transfer rate at the air-water interface defined in Section 4.2.2 and a surface area of 473 km^2 for the study area waterbodies, the range of current atmospheric loading is 2.1 to 5.8 kg/year.

4.3 MS4 Stormwater PCB Loading to Harbors and Nearshore Open Water Segments

In addition to the fact that Lake County, Shields Township, Waukegan Township, and the Cook County Highway Department have MS4 permits, 93.5 percent of the study area watershed lies within an MS4 city or village. As a result, close to 100 percent of the study area is within an MS4 area. However, no site-specific data were available to quantify stormwater PCB loads for the study area watershed (MWRDGC, 2015). The magnitude of stormwater PCB loads was therefore estimated as the product of runoff quantity, the study area drainage area, and an assumed stormwater PCB concentration, based on stormwater sampling outside the study area watershed. It was also conservatively assumed that all of the runoff generated within the study area watershed drained to Lake Michigan. The development of these inputs is described below.

Runoff quantity was calculated using the method developed by the Metropolitan Washington Council of Governments (Schueler, 1987) as **R = P * Pj * Rv**

Where:

R = Annual runoff (inches),

P = Annual rainfall (inches), estimated as 36.1 inches, based on the average annual rainfall reported for Chicago Midway Airport 3 SW for the 1929-2013 period (http://www.crh.noaa.gov/lot/?n=111577_Midway)

Pj = Fraction of annual rainfall events that produce runoff (set to the default of 0.9)

Rv = Runoff coefficient. Rv is a function of impervious cover in the study area watershed. Impervious cover was calculated using Geographic Information System (GIS) analysis for each major land use category: commercial (0.71), industrial (0.54), and residential (0.37). The following runoff coefficients resulted from these impervious cover values: commercial (0.69), industrial (0.54), and residential (0.38).

The area of the contributing watershed was calculated as 99.6 square miles, broken down as 3.82 square miles commercial, 4.05 square miles industrial, and 91.73 square miles residential. PCBs in urban stormwater have been studied in various watersheds in the United States, and they are ubiquitous. The PCB concentration was set to 7,270 pg/L, based on measurements from the City of Spokane (2014) collected from 2012-2014, which represented "typical" urban stormwater. The selected Spokane PCB concentration for estimating the stormwater PCB load was based on sampling in a watershed that has a land use distribution similar to that of the study area watershed, which is 73 percent residential, 4 percent commercial, and 19 percent open space.

The estimated stormwater PCB load for the study area equaled 1.36 lbs/year (0.62 kg/yr).

4.4 PCB Loading from Flow Reversals from the Chicago Area Waterways

The CAWS is a 76.3-mile branching network of navigable waterways controlled by hydraulic structures. The CAWS flow is composed of treated sewage effluent, CSO, and stormwater runoff, and dominant uses are conveyance of treated municipal wastewater, commercial navigation, and flood control. Flows from the CAWS ultimately drain to the Mississippi River, but on occasion, flows are reversed and flow into Lake Michigan.

There are two types of reversals: gate reversals and lock reversals. Gate reversals occur adjacent to the lock structure and involve small volumes of water. Lock reversals occur when the locks are opened during severe storms. Lock reversals allow a much greater volume of water to flow into Lake Michigan. During particularly large storms, lock reversals allow flow from the CAWS to discharge to Lake Michigan through the control works shown in Figure 2-5 (O'Brien Lock, the Chicago River Lock, and Wilmette Lock).

Limited site-specific data were available to quantify the magnitude of PCB loads from the CAWS flow reversals. The magnitude of loads entering the study area waters from periodic flow reversals of the CAWS was estimated based on measured flow and site-specific concentration data as described below. Because this estimate was uncertain, a second load calculation is provided, using site-specific flow data and PCB measurements from another location.

The volume of flow is reported by the Metropolitan Water Reclamation District of Greater Chicago (MWRD) on their website. http://www.mwrd.org/irj/go/km/docs/documents/MWRD/internet/protecting_the_environment/Combined_Sewer_Overflows/pdfs/Reversals.pdf. Until recently, the MWRD conducted water quality sampling in the CAWS in the vicinity of the control works during flow reversals, including measurements of PCBs. PCB loads were estimated based on concentration data collected twice at each sampling station during the 2013 flow reversals (Table 4-1), and the average 2010-2014 annual volume (4,021.4 million gallons) of water entering Lake Michigan through the three locks.

Table 4-1.Measured CAWS PCB Concentrations during Times of Flow Reversals

Location	Location of PCB sampling	Total PCB results (4/18/13)
O'Brien Lock	Calumet Harbor, 95th St. Bridge; Calumet Harbor, Ewing Ave. Bridge	All 4 samples < 0.3 ug/L
Chicago River Lock	Chicago River Locks, Inner Harbor Sluice Gate; Chicago River Locks, Sluice Gate, DuSable Harbor	Both samples < 0.3 ug/L
Wilmette Lock	Wilmette Harbor, Wilmette Pump Station	Both samples < 0.3 ug/L

Because all PCB concentration measurements were lower than the levels of detection, loads for this source could not be accurately quantified. However, total PCBs from this source can be estimated to be less than 100.7 lbs/yr (45.68 kg/yr), using the detection limit of 0.3 ug/L as the basis for an upper-bound estimate of PCB concentration. It is recognized that the PCB detection limit of 300,000 pg/L could be orders of magnitude higher than actual concentrations, such that this may be an extremely high upper-bound estimate.

To better assess the PCB load from CAWS flow reversals, in the absence of detectable concentrations of PCBs, it was assumed that CSOs comprise a significant portion of the CAWS flows (note that the actual composition of flows in the CAWS during periods of flow reversals is unknown (MWRDGC, 2015b)). Loads were calculated using the average 2010-2014 annual volume (4,021.4 million gallons) of water entering Lake Michigan through the three locks and observed PCB concentration data in CSOs collected by the City of Spokane (2014) using low detection limits, which provides a more realistic upper-bound PCB concentration.

Using the Spokane observed average PCB concentration of 12,420 pg/L for CSOs results in an upper-bound PCB loading estimate of less than 4.2 lbs/yr (1.9 kg/yr). The actual PCB concentration and load is expected to be less than this upper-bound estimate, because the flow reversals contain significant amounts of stormwater, which had a lower PCB concentration in the Spokane study.

4.5 Other Point Source PCB Discharges to the Study Area

Other point source PCB loads (in addition to permitted MS4 loads) were calculated based on permitted flow and measured concentration data, for facilities determined to have the potential to contribute PCB loads to the study area. These facilities were identified based on input and data provided by IEPA.

One facility (IL0002763, Zion Station) was determined to have the potential to contribute PCB loads to the study area waterbodies, based on permit monitoring requirements. All 23 effluent PCB measurements (2009-2014) were less than the 0.001 mg/L (1,000,000 pg/L) detection limit. Because all samples were less than the detection limit, point source loads could not be accurately quantified.

Based on the average measured flow (3.6 million gallons per day; MGD) and a concentration of 0.001 mg/L (set at the detection limit), the load is estimated to be less than 11 lbs/yr (5 kg/yr).

4.6 Resuspension and/or Pore Water Diffusion of PCBs from Bed Sediments

No site-specific data were available to define the magnitude of pore water diffusion and/or resuspension of PCBs into the study areas from bed sediments. The magnitude of pore water diffusion from bed sediments was estimated based on a combination of physical-chemical properties taken from the Lake Ontario PCB model (LimnoTech, 2004) with study area-specific measurements of sediment PCB concentrations. The properties taken from the Lake Ontario PCB model were bed porosity by volume (0.92), fraction organic carbon of bed sediment solids (0.02), bed sediment particle density (2.45 g/cm3), and the organic carbon partition coefficient for PCBs (106.1 m3/kg).

Results from the Lake Michigan Mass Balance Study (USEPA, 2006) indicate that sediment PCB concentrations over the study domain are on the order of 20 ng/g, resulting in a gross sediment flux of 0.012 kg/year across the entire study area. Lacking site-specific data on the magnitude of sediment resuspension for bed sediment PCBs, it can be reasonably assumed that this process is much smaller than sediment diffusion, given that this is a lake (rather than river) environment and that much of the sediment PCB re-deposits shortly after resuspension events.

4.7 Summary

Hydrodynamic transport of PCBs from the main body of Lake Michigan and atmospheric loading are clearly important loading sources (Table 4-2). No definitive determination could be made for stormwater loading, other point source discharges, or flow reversals from the CAWs, because site-specific PCB concentration data are either below detection limits or not available. While literature-based estimates for these sources indicate that they are likely to be minor contributors to the study area as a whole, they have the potential to be significant contributors to individual harbors.

Table 4-2. PCB Loads to the Study Area

Process	Data Sufficiency[a]	Estimated Magnitude
Hydrodynamic Transport from Main Body of Lake Michigan	Acceptable	4.6 to 13 kg/yr
Atmospheric Loading	Acceptable	2.1 to 5.8 kg/yr
MS4 Stormwater Loading	Limited. Rough estimate made using literature-based concentrations	0.62 kg/yr
Flow Reversals from the CAWs	Limited. Estimate of upper bound; all available data are non-detectable	<<1.9 kg/yr[3]
Other Point Source Discharges	Limited. Estimate of upper bound; all available data are non-detectable.	<< 5 kg/yr[4]
Resuspension and/or Pore Water Diffusion of PCBs from Bed Sediments	Limited. Estimated using site-specific sediment concentrations combined with literature values for diffusion rates.	0.012 kg/year

[a] Site-specific data sufficiency is characterized as limited (indicating the use of literature values and/or measurements less than the detection level) for the majority of the processes of concern, with hydrodynamic transport and atmospheric loading being the only sources quantified with existing data

[3] Using observed data from Spokane watershed with similar land use
[4] At detection limit 0.001 mg/L (1,000,000 pg/L)

5
Modeling Approach

This section describes the modeling approaches for calculating the PCB TMDL. A wide range of existing modeling frameworks could potentially be used to support development of the Illinois Lake Michigan Nearshore PCB TMDL. The TMDL Scoping Report (LimnoTech, 2015) reviewed the range of available frameworks and concluded that a zero-dimensional, steady state proportionality approach was most appropriate for this project, given the amount of data available to support TMDL development. This approach has been referred to as a "Level One" or "direct proportionality approach." Two different types of proportionality approaches were applied in developing the TMDL to determine the percentage of reduction needed to ensure that the resulting TMDL was protective of both the fish tissue and water column targets representing WQS for PCBs. One proportionality approach uses existing fish-tissue levels to estimate required load reductions, while the other approach is based on a gas phase equilibrium equation combined with bioaccumulation factors.

This section describes each approach and how they were applied to define the required reduction percentage that will meet TMDL targets. It is divided into the following sub-sections:

- Fish tissue-based direct proportionality approach
- Gas-exchange model direct proportionality approach
- Required reduction percentage

5.1 Fish Tissue-Based Direct Proportionality Approach

The approach for linking pollutant loads directly to fish tissue concentrations for this TMDL is patterned after the statewide mercury TMDL developed by the Minnesota Pollution Control Agency (MPCA, 2007), which drew from the work of Jackson et al. (2000), a regional mercury TMDL for the Northeast United States (CDEP et al., 2007), and statewide mercury and PCB TMDLs developed by the Michigan Department of Environmental Quality (LimnoTech, 2013; LimnoTech, 2012).

This approach is based on the following assumptions: 1) a reduction in PCB levels in the air will ultimately result in a proportional reduction in the overall rate of PCB deposition; 2) a reduction in PCB deposition will ultimately result in a proportional decrease in PCB loading to waterbodies; and 3) a proportional reduction in PCB loading into waterbodies will ultimately result in a proportional decrease in PCB concentrations in fish.

This can be expressed mathematically as:

$$C_{fish} = A * W_{Atm} \tag{5-1}$$

For purposes of TMDL development, Equation 5-1 can be rearranged to define the PCB loading rate that will attain compliance with fish tissue targets, as well as the percentage of reduction in loading necessary to attain those targets, i.e.

$$W_{Atm,TMDL} = C_{fish,target}/A \tag{5-2}$$

Where:

$W_{Atm,TMDL}$ = Atmospheric PCB loading rate necessary to attain compliance with TMDL
$C_{fish,target}$ = Target PCB concentrations in fish (mg/kg)
A = proportionality constant

The steady state conditions represented in the model correspond to long-term average fish tissue concentrations expected to eventually occur in response to long-term reduction in loading. Therefore, it is not expected that the proportional relationship between atmospheric deposition reductions and fish tissue reductions will be observed immediately. However, it is expected that the proportional response will be seen over the long term, once the systems have achieved a steady state. Even the most complex PCB TMDL models (e.g., DRBC, 2007; ICPRB, 2007) exhibit a linearly proportional response between external load and the resulting environmental concentration when applied to steady-state conditions.

Application of the fish tissue-based approach requires the selection of a target concentration (Section 3.3), an appropriate fish species, and calculation of a reduction percentage, also referred to as a reduction factor (RF).

5.1.1 Selection of a Target Fish Species

Fish tissue PCB concentrations have been sampled in a wide range of species across the study area, and they show varying degrees of bioaccumulation. The use of fish tissue samples from multiple species to form the basis for fish consumption advisories incorporates these varying degrees of bioaccumulation across the study area into the assessment for impairment of the fish consumption designated use.

Fish tissue PCB concentration data for 164 samples across 16 species of fish, spanning the collection period of 2000 to 2012, were used in the evaluation. PCB levels in carp tissue are the highest observed for all species of fish, and carp are also the most widely sampled species (Table 5-1.). Black bullhead have the second highest PCB concentration, but the sample is not large. Although lake trout have the third highest concentration and are less likely to be influenced by legacy concentrations of PCBs, they are not as widely distributed or sampled as carp.

Table 5-1. Mean Fish Fillet PCB Concentration (mg/kg) across Entire Study Area

Species	Count	Mean	Species	Count	Mean
Carp	52	4.329	Smallmouth Bass	7	0.172
Lake Trout	30	0.811	Pumpkinseed Sunfish	3	0.183
Black Bullhead	3	1.027	Alewife	6	0.187
Rock Bass	10	0.276	Round Goby	3	0.137
Sunfish	7	0.189	Yellow Perch	22	0.092
Largemouth Bass	4	0.225	Brown Trout	1	0.659
Bloater	7	0.270	Rainbow Trout	2	0.152
White Sucker	6	0.237	Rainbow Smelt	1	0.100

Carp tissue PCB data are not available for every impaired segment. As shown in Table 5-2. , the number of carp tissue samples available ranges from zero (Diversey Harbor, Calumet Harbor and the nearshore open water/shoreline) to 40 (Waukegan Harbor). While the majority of the carp measurements come from Waukegan Harbor, the conclusion that carp are the most contaminated species is not driven solely by results from Waukegan Harbor. PCB concentrations in carp from North Point Marina are similar to, and slightly higher on average than, PCB concentrations in carp from Waukegan Harbor. Because of the high concentration of PCBs in carp tissue, their comparatively large sample number, and their spatial distribution, the TMDL uses the fish tissue concentration in carp to represent baseline concentrations in fish. The reductions in the baseline fish tissue PCB concentrations that are needed to achieve the target PCB fish tissue concentration are used in the TMDL to determine the percentage reductions from PCB sources.

Table 5-2. Number of Carp PCB Fillet Samples and Mean Concentration by TMDL Zone

TMDL Zone	Count	Mean (mg/kg)
Nearshore Open Water/Shoreline	0	-
Calumet Harbor	0	-
North Point Marina	12	4.7
Waukegan Harbor	40	4.2
Diversey Harbor North	0	-

5.1.2 Consideration of Legacy Effects

Using carp in the fish tissue-based, direct proportionality approach selected for this TMDL necessitates careful consideration of the aquatic system's response to historical load reductions. This is due to a combination of two factors.

First, carp are benthic feeders and receive much of their PCB exposure from bottom sediments. Second, pollutant concentrations in bottom sediments respond much more slowly to pollutant load reductions than do pollutant concentrations in the water column. For this reason, the PCB concentrations in carp tissue reflect historical loading levels more than PCB levels in other fish species' tissue, because other fish receive the majority of their PCB exposure from the water column and water column-based food sources.

Carp tissue data available for this TMDL are shown in Figure 5-1. A historical decrease in tissue PCB concentration is apparent, with the fish tissue concentrations observed in 2005 being much lower than those observed in 2000 and 2001.

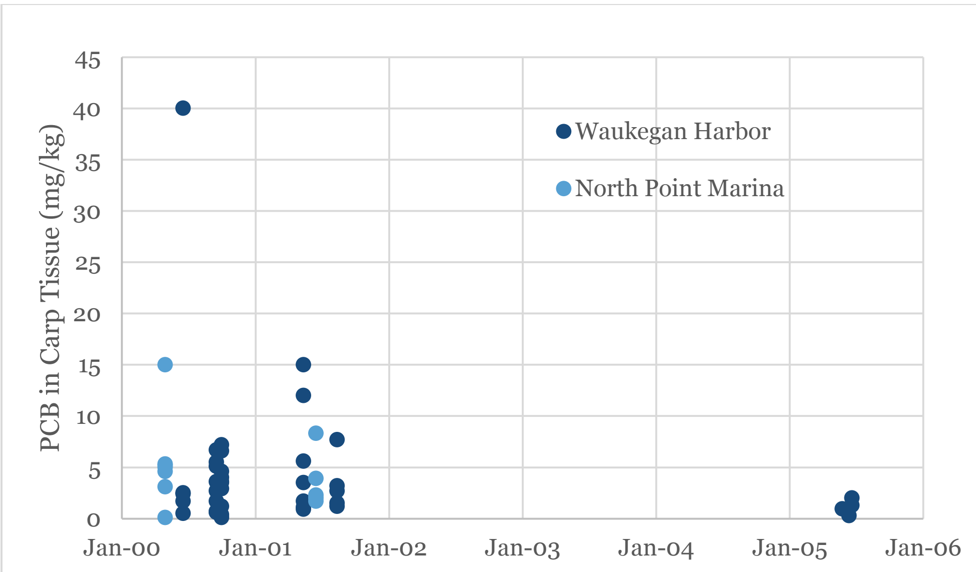


Figure 5-1. Carp Tissue PCB Concentration Data Available for TMDL

The use of carp tissue data in the fish tissue-based direct proportionality approach can lead to the requirement of unrealistically high load reductions, because this approach assumes that current fish tissue concentrations reflect only current loads. This effect can be demonstrated using the data in Figure 5-1. If a consideration of legacy sources was not necessary, the default proportionality approach would use all of the carp tissue concentration data (average = 4.3 mg/kg), which combined with the tissue target of 0.06 mg/kg in Equation 2 results in a required load reduction of 99 percent. If one assumes that the decrease in observed carp tissue concentration over time represents the decreasing importance of legacy sources (for example, reflecting additional clean-up of Waukegan Harbor PCBs in 2012 and 2013), and instead uses only the average of the most recent data for the current baseline (2005 average = 1.13 mg/kg), the required load reduction decreases to 94.7 percent.

The existing carp tissue PCB concentrations are known to reflect some combination of existing sources and legacy sources. Ideally, the TMDL would somehow adjust the existing tissue data to parse out how much of the current tissue contamination comes from existing versus legacy sources. Three specific options were considered:

- Development and application of a Level Three time variable mass balance model
- Empirical extrapolation of existing fish tissue data
- Censoring of existing fish tissue data

Theoretically, the parsing out of historical and current loading effects would require development and application of a time variable mass balance approach to both water column and sediments of the system, as described in the TMDL Scoping Report (LimnoTech, 2015). However, IEPA concluded that the data currently available are insufficient to support the application of a time variable framework.

A second option for accounting for the impact of legacy sources on estimated current PCB tissue contamination would consist of applying a statistical regression through the available fish tissue data, and subsequently using that regression to calculate expected existing concentrations. An exponential decay function was fit to the existing data using Excel, with the resulting regression shown in Figure 5-2. This regression, extrapolated out to 2015 conditions, results in a predicted PCB concentration in carp tissue of 0.2 mg/kg. This concentration is lower than that observed in several other fish species, and it could be used as justification for demonstrating that a TMDL based on protection of a different fish species would still be protective of carp.

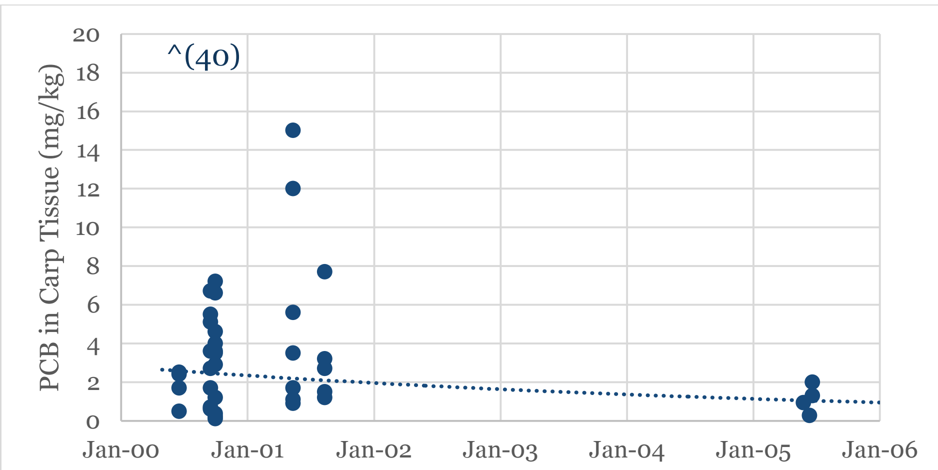


Figure 5-2. Exponential Regression Fit to PCB Concentrations in Carp Tissue

The drawback to this approach is that there is little basis on which to assume that the same rate of decay that occurred between 2000 and 2005 (which could be partially the result of external load reduction during that time, not just sediment decline) would take place between 2005 and 2015. In particular, EPA dredged PCB-contaminated sediments between 2009 and 2013, as a follow-up to the original removal of contaminated sediments in 1992. These factors result in extremely high uncertainty regarding the projected concentrations.

The third option for adjusting the data to minimize the effect of legacy loading is to use only the most recent (2005) carp data in calculating required load reductions. While it is expected that the 2005 carp tissue data still reflect some degree of legacy effect, the 2005 data alone clearly have less legacy influence than the combined 2000-2005 data set. As Figure 5-2 shows, the PCB concentration in the carp tissue data from 2005 is approximately 30 percent of the average PCB concentration from 2000-2005. Even at these reduced levels, however, carp have the highest concentration levels of all applicable species.

Based on the analysis above, applying the proportionality approach using the entire carp data set would disproportionately reflect legacy sources. Therefore, the approach taken for this TMDL is to use only the most recent (2005) carp data in calculating required load reductions. This will reduce most, but not all, of the legacy effect and result in a load reduction requirement more similar to that necessary to be protective of lake trout, a species with the third-highest mean PCB concentration, which isn't as strongly influenced by legacy sediment sources

5.2 Gas-Exchange Model Direct Proportionality Approach

The second approach that was used in the TMDL to implement the direct proportionality approach applied theoretical and empirically based equations to link atmospheric loading to the resulting PCB concentrations in the water column and fish tissue. This was done to determine if the calculated required load reductions for the water column will meet Illinois WQS and also to provide an alternate application of the direct proportionality approach for determining the load reductions necessary to protect fish tissue concentrations. This approach does not require existing fish tissue concentrations; therefore, it is not influenced by the legacy effect inherent in the existing carp tissue data. The gas-exchange model direct proportionality approach consists of the following steps.

1. Define the atmospheric PCB concentration that will result in compliance with WQS.
2. Define the relationship between steady state sediment PCB and water column concentrations.
3. Use published biota-sediment accumulation factors to define the relationship between steady state sediment PCB and carp tissue PCB concentrations.
4. Use published bioaccumulation factors to define the relationship between steady state water column PCB and lake trout tissue PCB concentrations

The application of each step to the Illinois Lake Michigan (nearshore) PCB TMDL is described below.

5.2.1 Atmospheric PCB Concentration that will Result in Compliance with WQS

Henry's Law, one of the gas laws in chemistry, states that the amount of a gas that dissolves in a liquid is directly proportional to the partial pressure (i.e. gas phase concentration) of that gas in equilibrium with that liquid. In mathematical terms, this can be stated as:

$$p = k_H c \qquad (5\text{-}3)$$

where

p = the partial pressure of the gas above the solution

k_H = a chemical constant termed the Henry's Law constant

c = the concentration of the dissolved gas in solution

Because the TMDL approach being taken represents steady-state conditions, Equation 5-3 can be adapted to define the atmospheric PCB concentration that will result in compliance with WQS. The adaptations are required because:

- Henry's Law applies to a single chemical at a constant temperature, while PCBs represent a mixture of individual chemicals, and the temperature of Lake Michigan varies seasonally.
- Henry's Law predicts only the dissolved phase PCB concentration in water, while total PCB concentrations consist of both dissolved and particulate forms.

The adaptations taken for this TMDL consisted of: 1) using a Henry's Law constant representative of the mixture of PCB congeners present in the Great Lakes (LimnoTech, 2004); 2) using an annual average temperature of 10^0C taken from USEPA (2006) MICHTOX model results for Lake Michigan; and 3) using fraction dissolved PCB in the water column of 0.67, also taken from the MICHTOX (USEPA, 2006) modeling. These adaptations resulted in a Henry's Law constant of 1.09 $\times 10^{-04}$ atm*m^3/mol at ambient temperature; when combined with a dissolved PCB fraction of 0.67, this constant results in an atmospheric concentration of 82 pg/m^3 being the equilibrium equivalent of a water column standard of 26 pg/L.

5.2.2 Relationship between Steady State Sediment PCB and Water Column Concentrations

One objective of the gas-exchange model direct proportionality approach is to define atmospheric PCB loads that will result in acceptable carp tissue PCB concentrations, via the application of biota-sediment accumulation factors (BSAFs). BSAFs estimate the relationship between pollutant concentrations in the bottom sediments and the pollutant concentration in the tissue of fish that obtain much of their pollutant exposure from these sediments. Accomplishing this objective requires a method of estimating sediment PCB concentration from atmospheric loading rates. Section 5.2.1 presented the linkage between atmospheric PCB concentrations and water column concentrations; this section defines the necessary linkage between water column concentrations and sediment concentrations.

The ratio between sediment and water column PCB concentrations can be defined as shown in equation 5-4 (Chapra, 1997):

$$C_2/C_1 = (V_sF_{p1} + V_dF_{d1}) / (k_2Z_2 + V_r + V_b + V_dF_{d2}) \tag{5-4}$$

Where:

C_2/C_1	= ratio of sediment PCB concentration to water column PCB concentration
V_s	= solids settling velocity (m/day)
F_{p1}	= fraction of PCB in particulate form - water column
k_2	= PCB decay rate in sediments (1/day)
Z_2	= sediment layer thickness (m)
V_r	= sediment resuspension velocity (m/day)
V_b	= sediment burial velocity (m/day)
V_d	= diffusion velocity
F_{d1}	= fraction of PCB in dissolved form - water column
F_{d2}	= fraction of PCB in dissolved form - sediments

Steady state values for all of the above coefficients were estimated for Southern Lake Michigan as part of development of the MICHTOX Lake Michigan Mass Balance Project (USEPA, 2006; Endicott, 2005; and Endicott et al., 2005), and are listed in Table 5-3.

Table 5-3. Coefficients for Equation 5-4

Parameter	Abbreviation	Value	Units
Settling Velocity	V_s	1.5	m/day
Diffusion Velocity	V_d	3.00×10^{-3}	m/day
Resuspension Velocity	V_r	3.42×10^{-7}	m/day
Burial Velocity	V_b	4.66×10^{-6}	m/day
Sediment Decay Rate	k_2	0.0	1/day
Sediment Layer Thickness	Z_2	0.033	m
Fraction Particulate Water Column	F_{p1}	0.3264708	none
Fraction Dissolved Water Column	F_{d1}	0.6735292	none
Fraction Dissolved Sediment	F_{d2}	3.84×10^{-5}	none
Fraction Organic Carbon, Surface	f_{oc1}	0.290	none
Fraction Organic Carbon, Sediment	f_{oc2}	0.052	none
Log Organic Carbon Partition Coefficient	$Log(K_{oc})$	6.32	Log(L/kg)
Sediment Particle Concentration	m_2	240	kg/m^3
Water Column Particle Concentration	m_1	0.8	g/m3
Sediment Particle Density	p	2.5	g/cc
Porosity	phi	0.904	none
Sediment Partition Coefficient	K_{d2}	0.109	m^3/g
Water Column Partition Coefficient	K_{d1}	0.606	m^3/g

Application of Equation 5-4 results in a steady state sediment/water column PCB ratio of 9.61×10^4. This ratio, when combined with the water column water quality standard for PCBs of 26 pg/L, results in a sediment PCB concentration of 2.50×10^{-3} g/m^3.

5.2.3 Relationship between Steady State Sediment PCB and Fish Tissue PCB Concentrations

The relationship between steady state carp tissue PCB concentrations and sediment PCB concentrations can be defined using a biota-sediment accumulation factor (BSAF), which is a parameter describing bioaccumulation of sediment-associated organic compounds or metals into tissues of ecological receptors. BSAFs can be used to calculate tissue concentrations using the following equation (Burkhard, 2009):

$$C_{FISH} = \frac{BSAF.\,C_{SED}.\,F_L}{F_{SOC}} \tag{5-5}$$

Where:

C_{FISH} = the chemical concentration in the organism (µg/kg wet weight)
$BSAF$ = the biota sediment accumulation factor (g organic carbon/g lipid)
F_L = the lipid fraction of the organism (g lipid/g wet weight)
C_{SED} = the chemical concentration in surficial sediment (µg/kg dry weight)
F_{SOC} = the fraction of the sediments as organic carbon (g organic carbon/g dry weight).

USEPA (2015d) maintains a database of approximately 20,000 BSAFs from 20 locations. This database was accessed to find the BSAFs for PCBs in carp. The most relevant values found were from Green Bay of

Lake Michigan, where the median BSAF was determined to be 3.3 g organic carbon/g lipid. The PCB database developed for this project was accessed to determine the median lipid content of carp fillets, which was determined to be 8.85 percent.

The above information was entered into Equation 5-5, with the result of a carp tissue PCB concentration of 0.0585 mg/kg being expected in response to a water column PCB concentration equal to the water quality standard of 26 pg/L. This indicates that a TMDL that is protective of the water quality standard would also be protective of carp tissue concentrations. It should be noted, however, that there is very high uncertainty around this estimate for the following reasons:

- Uncertainty analysis of the MICHTOX model indicated that results could vary within a factor of two, and likely by even more than that when applied to harbors.
- The lipid content of individual carp fillets used to calculate the average varied over several orders of magnitude.
- The observed BSAF values were from Green Bay, and not specific to the study area.

5.2.4 Relationship Between Steady State Water Column PCB and Lake Trout Tissue PCB Concentrations

The PCB concentrations in fish resulting from the PCB bioaccumulation process can be expressed as follows (USEPA, 1995; CDEP et al., 2007):

$$C_{fish} = BAF * C_{water} \tag{5-6}$$

Where:

C_{fish} = PCB concentrations in fish (mg/kg)
BAF = bioaccumulation factor which is constant (l/kg)
C_{water} = PCB concentrations in water (mg/l)

The revised Trophic Level 4 BAF from the Final Revisions to the Great Lakes Initiative (GLI) PCB human health criteria (Federal Register, 3/12/1997), which was calculated assuming a lipid fraction of 3.10 and a freely dissolved fraction of 0.6642, is 1,086,000. The information above was entered into Equation 5-6, with the result of a lake trout tissue PCB concentration of 0.028 mg/kg being expected in response to a water column PCB concentration equal to the water quality standard of 26 pg/L (2.6 x 10^{-8} mg/L). This indicates that a TMDL that is protective of the water quality standard for the water column would also be protective of tissue concentrations in lake trout, a species that is largely influenced by exposure to PCBs in the water column.

5.3 Required Reduction Percentage

As the previous sections indicate, the Illinois Lake Michigan (nearshore) PCB TMDL has multiple targets (i.e., water column concentration, tissue concentration in different species of fish) and multiple methods for determining the load reduction necessary to attain compliance with each target. Specifically, the following different applications of the direct proportionality approach were conducted:

1. Fish tissue-based approach to determine load reductions necessary to meet fish tissue targets, based on observed fish tissue data

2. Gas-exchange model direct proportionality approach to determine load reductions necessary to meet the water column water quality standard
3. Gas-exchange model direct proportionality approach to determine load reductions necessary to meet fish tissue targets, based upon relationships observed at other sites

This section calculates the required reduction percentage necessary to attain each target using each calculation method. It also provides a recommendation for which reduction percentage should serve as the basis for the TMDL.

The calculation of the required reduction target requires the specification of a baseline time period, since atmospheric PCB concentrations in the Great Lakes area have been decreasing over time (Venier and Hites, 2010b; Sun et al., 2006) in response to the ban on PCB production enacted in 1979. A baseline year of 2005 was selected for this TMDL for the following reasons:

- The carp tissue data used in the fish tissue-based approach were all collected in 2005.
- The lake trout tissue data used in the fish tissue-based approach were all collected between 2000 and 2009.
- The two scientific papers that document the decline in atmospheric PCB concentrations (Venier and Hites, 2010b; Sun et al., 2006) are based on data sets that end in 2007 and 2003, respectively. Estimating present-day PCB concentrations using these regressions would require a major extrapolation to time periods roughly 10 years beyond the data set used to develop the regression.

5.3.1 Fish Tissue-Based Approach

Equations 5-1 and 5-2 can be rearranged to calculate a required reduction percentage as follows:

$$\%\,Reduction = 100 \times \left(C_{fish,current} - C_{fish,target}\right)/C_{fish,current} \quad (5\text{-}7)$$

Where:

$C_{fish,current}$ = current PCB concentrations in fish (mg/kg)
$C_{fish,target}$ = target PCB concentrations in fish (mg/kg)

Equation 5-7 was applied using the average PCB concentration of the 2005 carp data (1.13 mg/kg) in conjunction with the fish tissue target of 0.06 mg/kg to calculate a required load reduction of 94.7 percent. Equation 5-6 was also applied using the average PCB concentration of all lake trout data (0.811 mg/kg) to calculate a required load reduction of 92.6 percent.

5.3.2 Gas-Exchange Model Direct Proportionality Approach

The gas-exchange model direct proportionality approach can be applied to calculate the required reduction in PCB loading necessary to meet the following TMDL targets:

- Water column total PCB concentration
- Carp tissue target
- Lake trout tissue target

The load reduction required to meet the water column total PCB concentration target can be determined by rearranging Equation 5-7 as follows:

$$\% \, Reduction = (C_{atm,current} - C_{atm,target})/C_{atm,current} \tag{5-8}$$

Where:

$C_{atm,current}$ = current atmospheric PCB concentrations (pg/m^3)

$C_{atm,target}$ = atmospheric PCB concentrations necessary to comply with water column criterion, as defined by (pg/m^3)

Section 4.4 explained the conclusion that the Simcik et al. (1997) data provided the best estimate of nearshore over-lake PCB measurements and showed an annual average atmospheric concentration of 529 pg/m3 for the period 1994-1995. Combining that value with the half-life of 7.7 years for Chicago-area atmospheric PCB concentrations results in a 2005 concentration of 197 pg/m3. Application of Equation 5-3 above showed that an atmospheric concentration of 82 pg/m3 was required to attain an equilibrium equivalent water column standard of 26 pg/L. Combining the current concentration of 197 pg/m3 and the target concentration of 82 pg/m3 in Equation 5-8 results in a required reduction percentage of 58 percent.

Application of the BSAF in Section 5.2.3 showed that a water column PCB concentration of 26 pg/L would be expected to result in a carp tissue concentration of 0.0585 mg/kg, which is essentially equal to the fish tissue target of 0.06 mg/kg. For this reason, the 58-percent reduction in atmospheric concentration determined above as necessary to meet the water column target would also be required to meet the carp tissue target.

Application of the Trophic Level 4 bioaccumulation factor in Section 5.2.4 indicates that a water column PCB concentration of 56 pg/L would result in compliance with the tissue target of 0.06 mg/kg. This water column concentration corresponds to an atmospheric PCB concentration of 177 pg/m3. Combining the current concentration of 197 pg/m3 and the target concentration of 177 pg/m3 in Equation 5-8 results in a required reduction percentage of 10 percent.

5.3.3 Recommended Reduction Percentage

Reduction percentages have been calculated to range from 10 to 94.5 percent, corresponding to different targets and different calculation methods. Overall, the fish tissue-based approach results in a greater required reduction percentage (92.6 to 94.7 percent) than the gas-exchange model direct proportionality approach (10 to 58 percent). It is noted that the gas exchange model only considers current atmospheric sources, while the fish tissue approach reflects the influence of historical and non-atmospheric loads. Given that atmospheric sources were shown to be the dominant source of PCBs to the study area, the higher reduction percentage required by the fish tissue approach likely indicates that current carp and lake trout tissue concentrations exhibit a significant legacy effect reflecting historically higher loading rates. Nonetheless, it is recommended that the 94.7-percent reduction resulting from the fish tissue-based approach for carp be used as the basis for the TMDL. There are two primary reasons for this recommendation.

- The uncertainty in these estimates is high for several reasons (e.g., limited number of fish tissue samples available), and use of the upper bound of the range of reduction percentages meets the TMDL requirement of providing a margin of safety (MOS) to account for uncertainty.
- It will take decades for the legacy effect to diminish. While a 58-percent reduction in loading may be all that is required to attain targets, selection of a larger reduction percentage will allow

the targets to be attained more quickly. This concept is illustrated in Figure 5-3, which demonstrates the 58 percent reduction eventually reaching the target fish tissue level of 0.06 mg/kg. The 94.7 percent reduction, on the other hand, ultimately attains a target level much less than the target of 0.06 mg/kg, but attains the target concentration decades sooner than the 58% reduction.

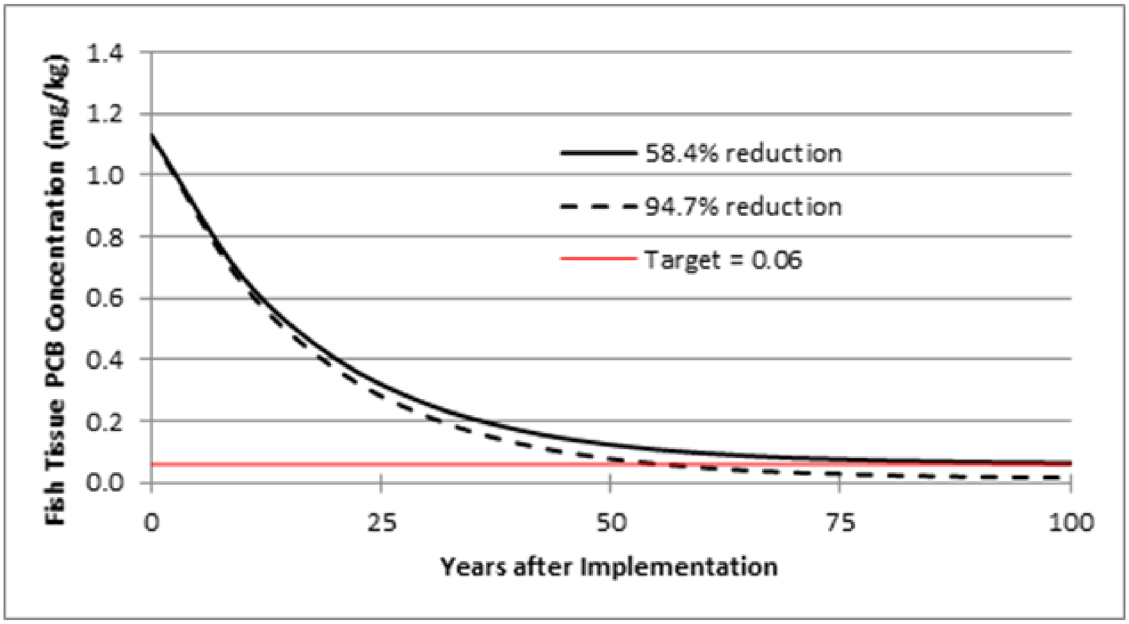


Figure 5-3. Illustration of Fish Tissue PCB Concentration Over Time, Under Two Reduction Scenarios

6
TMDL Development

A TMDL calculates the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet the WQS for that particular pollutant, in this case for PCBs. The TMDL allocates the maximum allowable load to point sources (Wasteload Allocation, or WLA), and nonpoint sources (Load Allocation, or LA), which include both anthropogenic and natural background sources of the pollutant. TMDLs must also include a margin of safety (MOS) to account for uncertainty in the relationship between pollutant loading and receiving water quality, and account for seasonal variations.

The TMDL is typically defined by the equation:

$$TMDL = \sum LA + \sum WLA + MOS \tag{6-1}$$

Where

TMDL = total maximum daily load (i.e., the loading capacity (LC) of the receiving water)

$\sum$LA = sum of all load allocation for nonpoint sources

$\sum$WLA = sum of all wasteload allocation for point sources

MOS = margin of safety

The process to determine the TMDL includes:

1) Determine the LC of the receiving water(s) (i.e., the maximum pollutant load that the waterbody can assimilate and attain WQS)
2) Allocate this loading capacity among the three categories shown in Equation 6-1

Equation 6-2 is used to calculate the TMDL using the existing combined load of PCBs from point and nonpoint sources, defined as the “baseline load,” and the reduction factor (RF):

$$TMDL = Baseline\ Load * (1-RF) \tag{6-2}$$

Where

TMDL = total maximum daily load (mass/time);

Baseline load = total source load during the baseline year of 2005 (including all air sources and NPDES permitted discharges of PCBs);

RF = reduction factor.

The RF is based on the reductions needed to achieve target fish PCB concentrations (see Equation 5-7 in Section 5.3.1). An annual load is the most appropriate way to calculate this PCB TMDL because the goal is to address long-term PCB bioaccumulation, rather than to track short-term effects. Nonetheless, TMDLs are recommended to be expressed in daily units whenever feasible. Consistent with the Michigan statewide PCB TMDLs (LimnoTech, 2012), a maximum allowable daily load can be estimated by examining the intra-annual variability in loading and determining the highest daily load expected to occur within a year that meets the annual average target.

This section presents the calculation of the TMDL, and is divided into the following sections:

- Baseline PCB load
- TMDL loading capacity
- Wasteload allocation
- Load allocation
- Margin of safety
- Critical conditions and seasonal variation

6.1 Baseline PCB Load

The baseline load is the sum of the existing nonpoint and point source loads of PCBs for the baseline year. As discussed in Section 5.3, the year 2005 was selected as a baseline year because it most closely matches the timing of the fish tissue samples used as the basis of the TMDL.

Diffuse, or nonpoint, sources of PCBs to the study area consist primarily of atmospheric exchange, either directly to the study area or indirectly via atmospheric exchange with the main body of Lake Michigan and subsequent transport into the study area. Table 4-2 indicates that PCB loading to the study area due to hydrodynamic transport from the main body of Lake Michigan ranges from 4.6 to 13 kg of PCB per year, while direct atmospheric exchange to the study area contributes 2.1 to 5.8 kg/yr. These loads are expressed as ranges, accounting for the fact that atmospheric loads are decreasing over time. Normalizing these loads to the baseline year of 2005 results in a hydrodynamic transport load from the main body of Lake Michigan equal to 7.4 kg of PCB per year, and a direct atmospheric load of 4.9 kg/yr. The sum of these numbers, 12.3 kg/yr, represents the nonpoint source load for the baseline year of 2005.

Point sources of PCBs consist of regulated wastewater and stormwater discharges (including permitted municipal separate storm sewer system (MS4) discharges). Stormwater regulated under the NPDES stormwater program (i.e., Phase I and Phase II) is a point source. No detectable PCB concentrations were available for any of the NPDES discharges in the study area, and no data are available for the stormwater discharges. The source assessment conducted in Section 4 indicated that these sources are likely a small contributor to existing PCB loads to the segment (Table 4-2). As such, point sources are not included in the baseline loading allocation. Point sources will receive a WLA, however, to ensure that future loads do not lead to a WQS violation.

The baseline total source load is the sum of the baseline point source load and nonpoint source load. Because the only detectable load of PCBs is from nonpoint sources, the baseline load for 2005 is equal to the nonpoint source load and is 12.3 kg/yr (Table 6-1).

Table 6-1. Baseline PCB Load for 2005

Portion of Baseline PCB Load	Result
Point Source Load	No detectable load *
Nonpoint Source Load	12.3 kg/yr
Total Baseline Load (2005)	12.3 kg/yr

* - See discussion above for further explanation

6.2 TMDL Loading Capacity

The baseline load described in Section 6.1 and the reduction factor (RF) described in Section 5.3 are used to define the TMDL Loading Capacity by applying the RF to the baseline load, as shown in Equation 6-3.

$$\text{TMDL} = \text{Baseline Load} \times (1\text{-RF})$$

$$0.65 = 12.3 \times (1 - 0.947) \qquad (6\text{-}3)$$

Inserting the baseline load (12.3 kg/yr) and RF (94.7 percent) into Equation 6-3 yields a TMDL of 0.65 kg/yr. TMDLs are recommended to be expressed in daily units whenever feasible. Consistent with the Michigan Statewide PCB TMDLs (LimnoTech, 2012), a daily load can be estimated by examining the intra-annual variability in loading and determining the highest daily load expected to occur within a year that meets the annual average target. As noted previously, the total nonpoint source load consists of two components: an atmospheric PCB load and PCB transport from Lake Michigan. The intra-annual variability in these two source categories was assessed separately. The variability in atmospheric loading was calculated by taking the highest observed single-day atmospheric PCB concentration in Simcik et al. (1997), and dividing that by the annual average concentration to get a ratio for daily maximum to annual average concentration of 2.1, using the equation

Maximum daily atmospheric load =

Total annual load x Ratio of atmospheric: total load x Ratio of daily maximum: annual average (6-4)

Application of Equation 6-4 results in a maximum daily load attributable to direct atmospheric exchange of:

$$0.65 \text{ kg/yr} \times (4.9/12.3) \times 2.1 \div 365 \text{ days/yr} = 0.0015 \text{ kg/day}$$

It can be reasonably assumed that Lake Michigan PCB concentrations do not vary substantially over the course of a year, so the daily load for transport from Lake Michigan is calculated as the annual load divided by 365, i.e.:

Maximum daily Lake Michigan transport load =

Total annual load x Ratio of transport: total load (6-5)

Application of Equation 6-5 results in a maximum daily load attributable to transport from Lake Michigan of:

$$0.65 \text{ kg/yr} \times (7.4/12.3) \div 365 \text{ days/yr} = 0.0011 \text{ kg/day}$$

The resulting maximum daily loading capacity is the sum of those two loads, or 0.0026 kg/day (=0.0015 kg/day+0.0011 kg/day). To be clear, this does not mean that the load can be 0.0026 kg/day every day of the year. This means that, given expected seasonal variability in atmospheric concentrations, if the highest daily load is 0.0026 kg/day, then the annual load will not exceed the target of 0.65 kg/yr. For example, the average daily loading rate from atmospheric sources is 0.00071 kg/day. Seasonal variation in atmospheric concentrations are such that this loading rate can be as high as 0.0015 kg/day on the worst day of the year. These seasonal variations also dictate that atmospheric loading will be much less than the average value of 0.00071 kg/day on other days of the year.

This is the daily allowable load of PCBs that, over time, is expected to result in meeting the fish tissue target for PCBs of 0.06 mg/kg, and attaining WQS.

6.3 Wasteload Allocation

The WLA is defined as the portion of the loading capacity allocated to NPDES-permitted point sources, including MS4 stormwater. Even though point source PCB loads were determined to be small compared to current nonpoint source loads, it is important to ensure that these loads will not cause or contribute to a violation of the WQS after reductions of nonpoint sources occur. The only way to ensure that these sources maintain compliance with WQS is to establish WLAs for these sources that are designed to attain WQS at the point of discharge. This TMDL, therefore, establishes WLAs for MS4s to ensure that PCB loadings from these sources attain WQS. Entities in the study area with MS4 permits are listed in Table 6-2.

Table 6-2. Study Area Entities with MS4 Permits

Place Name	MS4 Permit Number	Place Name	MS4 Permit Number
Beach Park	ILR400164	**Lake Forest**	ILR400367
Chicago	ILR400173	**North Chicago**	ILR400402
Cook County Highway Department	ILR400485	**Shields Township**	ILR400123
Evanston	ILR400335	**Waukegan**	ILR400465
Glencoe	ILR400198	**Waukegan Township**	ILR400148
Highland Park	ILR400352	**Wilmette**	ILR400473
Highwood	ILR400353	**Winnetka**	ILR400476
Kenilworth	ILR400214	**Winthrop Harbor**	ILR400477
Lake Bluff	ILR400366	**Zion**	ILR400482
Lake County	ILR400517		

The WLA associated with these stormwater discharges is determined by multiplying the magnitude of stormwater flow delivered to the study area from each of these sources (calculated in Section 4.3) by a concentration equal to the water quality standard in order to convert it to a load. This results in a stormwater MS4 WLA of 0.0022 kg/yr (0.000006 kg/day).

6.4 Load Allocation

The LA, presented in Table 6-3, is essentially[5] equal to the loading capacity of 0.0026 kg/day calculated in Section 6.2. As defined in Section 6.2, the LA consists of two components: direct atmospheric exchange of PCBs to the study area and transport of PCBs into the study area from Lake Michigan (which also originate from atmospheric deposition).

Table 6-3. PCBs Load Allocation

Portion of Load Allocation	Result
Direct atmospheric exchange	0.0015 kg/day
Transport from Lake Michigan	0.0011 kg/day

The calculations in Section 5 demonstrated that a 94.7-percent reduction in atmospheric PCB concentration is necessary to attain PCB levels that are protective of designated uses. This TMDL only has regulatory authority over PCBs originating from within the state of Illinois. For that reason, it is necessary to divide existing PCB concentrations into separate components corresponding to: (1) out-of-state sources; and (2) within-state sources. The PCB contribution due to out-of-state sources was defined for this TMDL by the PCB concentration measured in 2005 at the remote Eagle Harbor, Michigan monitoring station of the Integrated Atmospheric Deposition Network, which is 53 pg/m^3 (USEPA, 2015b). It is difficult to predict the origin of atmospheric PCBs from outside the state. Atmospheric mixing processes are very complex and change constantly. Over time, PCBs being deposited on Lake Michigan could come from as far away as China (University of Minnesota and LimnoTech, 2009; MacLeod et al., 2005). The PCB contribution from in-state sources was defined as the difference between the total atmospheric PCB concentration over the nearshore study area (197 pg/m^3) and the concentration attributed to out-of-state sources. In-state sources make up 73 percent of the study area's atmospheric PCB concentration, while out-of-state sources make up the remaining 27 percent.

If the TMDL was designed solely to reduce in-state sources, the necessary reductions from these sources would be calculated using Equation 6-4:

$$\% \text{ reduction in in-state deposition} = RF / (1 - \% \text{ out-of-state contribution}) \qquad (6\text{-}4)$$

Where

RF = required reduction factor in overall concentration

Given a required reduction factor of 94.7 percent, and an out-of-state contribution of 27 percent, Equation 6-4 indicates that in-state sources would need to be reduced by 130 percent if no reductions are made to out-of-state sources. In-state reductions in PCB atmospheric deposition will not achieve the TMDL target alone. Therefore, this TMDL assumes that reductions from out-of-state sources will be consistent with those required for in-state sources (i.e., a 94.7-percent reduction will be required for both in-state and out-of-state sources). It is important to recognize, however, that even though reductions in in-state PCB concentrations alone will not attain compliance with WQS, reduction in in-

[5] A portion of the load capacity will be allocated to point sources, but this portion is within the round-off error of load allocation

state sources closer to background levels will lead to significant improvement in fish tissue levels. Table 6-4. presents the baseline and target atmospheric PCB load for Illinois in-state sources.

Table 6-4. Summary of Baseline and Target Atmospheric PCB Load from Illinois In-State Sources

Category	Atmospheric PCBs Load
2005 Estimated In-State Atmospheric Load	8.4 kg/yr
Target Reduction Rate in Illinois' Atmospheric Load	94.7%
2005 Target In-State Atmospheric Load[a]	0.45 kg/yr

[a]Calculated as 2005 Estimated Instate Atmospheric Load x (1-0.947)

6.5 Margin of Safety

The MOS is a required part of the TMDL to account for technical uncertainties such as model predictions, analysis of technical data, and the relationship between pollutant loading and receiving water quality. When calculating the TMDL, the MOS can be explicit (e.g., stated as an additional percentage of load reduction), implicit (e.g., conservative assumptions in the TMDL calculations or overall approach), or a combination of the two. For this PCB TMDL, the MOS is implicit through the use of carp tissue data as the basis for calculating required reduction percentages. Although the most recent available carp data were selected for use in this TMDL, the data likely reflect legacy PCB loads to some extent, because the average life span of carp is 8 to 15 years, with a maximum of 47 years (Becker, 1983). Calculation of required reduction percentages using alternate methods not influenced by legacy effects results in much lower required reduction percentages. Calculating the TMDL based on this high average PCB tissue concentration incorporates an implicit MOS into the analysis.

6.6 Critical Conditions and Seasonal Variation

TMDLs are required to consider seasonal variations and critical environmental conditions [40 CFR§130.7(c)(1)]. PCB concentrations in the atmosphere and water column can fluctuate seasonally. However, PCBs accumulate in fish tissue more slowly than seasonal fluctuations occur, and the increases do not correspond to seasonal variations. Instead, the PCB concentration in the fish represents an integration of all temporal variation up to the time of sample collection. Variability in fish tissue PCB concentrations are more likely influenced by differences in size, diet, habitat, and other undefined factors that are expected to be greater in sum than seasonal variability (MPCA, 2007).

There are critical conditions in the sense that certain waterbodies and fish species are more likely to bioaccumulate PCBs due to individual water chemistry characteristics and the biochemistry of individual fish species. This aspect of critical conditions has been addressed in this TMDL by using a fish species known to have high bioaccumulation potential. Thus, the critical conditions are assumed to be adequately addressed in the existing analysis.

6.7 TMDL Summary

The components of the PCB TMDL are summarized in Table 6-5.

Table 6-5. Summary of TMDL Components

TMDL Components	Results
Target Level and Reduction Factor	
Target Fish PCB Concentration (Fish Tissue Residue Value)	0.06 mg/kg
Baseline PCB Concentration for Carp	1.13 mg/kg
Reduction Factor	94.7 %
PCB Load for Baseline Year 2005	
Point Source Load	No detectable load
Nonpoint Source Load	12.3 kg/yr
Transport from main body of Lake Michigan	7.4 kg/yr
Direct atmospheric load	4.9 kg/yr
Total Baseline Load	12.3 kg/yr
Final TMDL	
Loading Capacity (LC)	0.0026 kg/day
Necessary Reduction from Atmospheric Sources	94.7%
Margin of Safety (MOS)	Implicit
Wasteload Allocation (WLA)	0.000006 kg/day l
Load Allocation (LA)	0.0026 kg/day
PCB Load Allocation for In-State and Out-of-State Deposition Sources	
In-State Contribution to LA[a]	0.0019 kg/day
Out-of-State Contribution to LA[b]	0.0007 kg/day

Numbers may not sum exactly due to rounding

[a] Calculated as 73% of LA

[b] Calculated as 27% of LA

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7
Implementation Plan and Monitoring Recommendations

To achieve the PCB wasteload and load allocations described in Section 6, PCB loads must be significantly reduced. Atmospheric PCB loads are the most significant source of PCBs to the study area waterbodies (either through direct atmospheric exchange or indirectly through transport from portions of Lake Michigan outside the study area), with estimates of other point and nonpoint sources contributing a much smaller proportion. The IEPA Bureau of Water/Watershed Management Section-Planning Unit, which includes the TMDL program, has no direct regulatory control over sources of PCB to the atmosphere. TMDLs that call for reduction in sources for which an NPDES permit is not required should provide a reasonable assurance that the controls will be implemented and maintained.

Monitoring data over the last several decades have shown a steady and steep decline in gas phase atmospheric PCB concentrations in the Great Lakes region (Figure 2-2). This decline can be attributed to the ban on the manufacture and use of PCBs in the United States in the 1970s. PCBs are removed from the environment via several mechanisms: replacement of PCB-containing equipment with non-PCB containing equipment, proper disposal of PCB-containing oils and equipment, and identification and modification of processes that inadvertently create PCBs. The PCB ban and subsequent removal of PCBs from the environment is reflected in the downward trend of atmospheric PCB concentrations. The implementation actions discussed in this section may accelerate this rate of decline, by actively removing historical sources of PCBs that have been previously volatilizing and contributing to elevated atmospheric PCB concentrations.

NPDES-permitted point sources including MS4 stormwater runoff, while not estimated to be the primary source of PCBs to the study area, must also be controlled to ensure that water quality targets are attained. This section provides best management practices (BMPs) for reducing PCBs in runoff, as well as specific language to include in MS4 permits.

This section provides recommendations for actions to reduce PCBs in the environment, and ways to monitor progress. It is divided into the following sections:

- Potential sources to target for PCB control
- BMPs for reducing PCB loads
- Funding opportunities
- Reasonable assurances for achieving the TMDL target
- Monitoring recommendations to track TMDL effectiveness

7.1 Potential Sources to Target for Control

This TMDL calls for control of two broad categories of PCB sources: atmospheric loads and point sources. Atmospheric PCB loads can be reduced through the targeted reduction of PCBs in Illinois, thereby limiting the amount of PCBs that volatilize into the atmosphere. Point source loads, consisting primarily of municipal stormwater, can be controlled either by reducing the amount of PCBs entering the stormwater system and/or treating the stormwater itself. The identification of PCB sources contributing to the atmosphere and stormwater is a difficult but important step. The discussion that follows provides some guidance on identifying potential PCB sources using existing information.

7.1.1 Identification of Potential PCB-Containing Products

Due to the ban of production of PCBs in 1979, PCBs that remain in the environment today are a result of: 1) cycling of PCBs from historical/legacy uses, and 2) new sources, inadvertently produced as by-products of chemical manufacture. The most common historical uses for PCBs were capacitors (50.3 percent) and transformers (26.7 percent), followed by a variety of other industrial uses such as plasticizers, hydraulic fluids, carbonless copy paper, and heat transfer fluids (USEPA, 1994). Watershed-specific data on legacy sources is unavailable, but more specific data from the U.S. on legacy PCB uses and sources can be found in Appendix B. As mentioned in the source assessment section (Section 4), PCBs from legacy sources volatilize into the atmosphere or are released into stormwater runoff via contaminated sediment. Thus, cleaning up existing sources is important to prevent future release or discharge.

Despite the ban on the intentional production of PCBs, there is still widespread inadvertent production of PCBs during the manufacture of chemicals. Hu and Hornbuckle (2010) reported that a PCB that was not produced as part of the banned Aroclor mixtures, was reported in air samples collected in Chicago, Philadelphia, the Arctic, and several sites around the Great Lakes. In Chicago, the congener 3,3'-dichlorobiphenyl (PCB11) was found to be the fifth most concentrated congener and ubiquitous throughout the city, exhibiting a seasonal concentration trend suggesting volatilization from outdoor surfaces. Hu and Hornbuckle (2010) detected PCB congeners in pigments commonly used in paint, inks, textiles, paper and other products. The U.S. Toxics Substance Control Act provides exemptions for PCBs as unintentional contaminants in manufacturing processes, allowing for PCB concentrations of up to 50 ppm in certain products.

For a list of those chemical processes that have the potential to generate new PCBs and reported cases of inadvertently produced PCBs, see Appendices D and E, respectively, in Washington Department of Ecology (2014)

7.1.2 Point Sources

NPDES-permitted point sources, primarily MS4 stormwater runoff, are the second category of PCB sources to be controlled through this TMDL. Though estimated to be a relatively small source compared to atmospheric loading, stormwater can transport PCBs from air deposition, demolition dust and contaminated soil to waters and add to PCBs available to bioaccumulate in the aquatic food chain. Establishing BMPs in MS4 permits that are consistent with the TMDL would break this cycle with the added potential benefit of reducing other pollutants loads and stormwater peak flow velocities and volumes. In order to ensure future MS4 loads meet the TMDL, the MS4 WLA will be addressed in permits issued by IEPA requiring the implementation of BMPs.

Examples of BMPs to implement for reducing PCBs in runoff are provided in Section 7.2 and specific language to include in MS4 permits is provided in Appendix C.

7.2 Best Management Practices (BMPs) for Reducing PCB Loads

This section describes the different types of BMPs that will be used to reduce PCB loads to the nearshore waters of Lake Michigan, and describes their appropriateness based on location/source. These BMPs are expected to reduce PCBs from both nonpoint sources and MS4 runoff. Table 7-1. provides information on the implementation points, sources, and pathways for the range of BMPs. Table 7-2. summarizes the level of effectiveness achieved in reducing contaminant loads to the storm sewer system for the range of BMPs described below.

7.2.1 Institutional BMPs

Institutional BMPs are focused on information sharing and governmental practices to help businesses and the general public avoid, or clean up and properly dispose of, products containing PCBs. These BMPs require the least amount of infrastructure, engineering work, maintenance, and disturbance of existing land, because their purpose is to avoid the continued use, inadvertent production, or release of PCBs. The institutional BMPs listed below will help reduce PCB loads to the atmosphere through cleaning up existing sources and properly disposing of PCB-containing products and waste.

- Conduct public education and outreach campaigns to facilities, local officials, and demolition/construction contractors to spread information about the potential sources of PCBs, what to do with them if discovered, and safer alternatives. Information should be shared with buyers and suppliers of industrial equipment, consumers, and residents who fish for recreation or subsistence, to increase their awareness of fish advisories and the fish species that contain the highest concentrations of PCBs. The effectiveness of an education and outreach campaign may be increased by educating those more likely to come into contact with PCBs.
- Conduct a survey of the state's utilities and other owners of electrical equipment to confirm the presence of PCBs in transformers inventoried in the EPA database mentioned above (EPA 2011a). Provide technical assistance where requested for disposal and replacement of the contaminated fluid (Washington State Department of Ecology, 2014).
- Promote wider/higher use of recycling facilities, to reduce the presence of light ballasts, drums, old transformers, capacitors, etc.
- Develop and implement take-back programs: government- or non-profit-run programs to accept PCB-containing waste.
- Prevent more material from being washed down streets, to prevent it from entering storm drains. Conduct targeted street sweeping: modify street sweeping frequency and the areas covered to target sources of PCBs.
- Clean up illegally dumped waste, such as old drums, electrical equipment, or building demolition material, that may have PCB-contaminated caulk or paint to prevent dust from entering air or water.
- Review local/regional laws regulating waste disposal, and revise as necessary: this could include implementing fines for improperly disposing of PCBs and sharing information on safer alternatives for lighting, paint, caulk, etc.

7.2.2 Contaminated Sites and Soil Remediation BMPs

These BMPs involve identifying and cleaning up soil that has been contaminated from past use of PCBs. It is important to identify and remediate this contaminated soil before it can be mobilized and transported into the storm drain system, especially during wet weather, to avoid further discharge and distribution into Lake Michigan and its tributaries. In addition, remediation of contaminated soil and sites will prevent further contributions to atmospheric concentrations of PCBs. Significantly more equipment use and land disturbance are required for these solutions than the institutional control addressed previously. Examples of contaminated site and soil remediation BMPs include:

- Identification and elimination of storage or use of PCBs: removal of old equipment or drums of PCBs and proper disposal, in addition to soil remediation if PCBs have been spilled.
- Building remodeling or demolition: identification of older building that may contain PCBs and replacement of the fixtures with safer alternatives, or removal of the buildings altogether. Common options include:
  - Removal of caulking installed before 1979 that contains PCBs
  - Identifying and disposing of light ballasts, surfaces painted with PCB-containing paint, etc.

7.2.3 Treatment Control BMPs (MS4 Stormwater BMPs):

These BMPs are engineered options to be installed or built with the existing storm sewer infrastructure to capture soil containing PCBs and prevent it from being discharged to Lake Michigan. Since PCBs adsorb to soil/sediment, reducing solids will in turn reduce PCBs. These BMPs can be implemented anywhere, but the limiting factor is access, because they require regular inspection and maintenance and specialized knowledge for installation. These BMPs are effective at treating a range of contaminants and are not limited to controlling PCB loads. They are organized by their placement relative to storm sewer pipes. Appendix C provides a menu of BMPs to facilitate reductions in PCBs from stormwater consistent with the goals of this Lake Michigan Illinois Nearshore TMDL. These BMPs can be applied at three different locations within the stormwater systems:

- Pipe entrance
  - Capture of PCBs before they enter stormwater pipes
  - Includes infiltration trenches, basins, retention and reuse (rain barrels or underground tanks), ponds, detention basins, swales, buffer strips, bioretention
- Installed within MS4 pipes:
  - Includes filters, screens, wet vault[6], hydrodynamic separators
  - Usually have high maintenance requirements and can sometimes back up flow when not maintained properly
- End of pipe
  - Includes sedimentation basins, constructed wetlands, or diversion of flow to treatment at wastewater treatment plants

[6] A wet vault is a permanent pool of water in a vault that rises and falls with storms and has a constricted opening to let runoff out. Its main treatment mechanism is settling of solids that are contaminated.

Table 7-1. BMP Application for Controlling PCBs in Urban Areas Relative to Sources (Source: San Francisco Estuary Institute 2010)

	Implementation Points								Applicable sources and pathways	
	Dispersed								PCBs	
Best Management Practice (BMP) Category	Private homes	Public lots, schools, hospitals, govt bldgs and research institutions	Private offices and businesses	Other private lots and industrial yards	On the street	Start of pipe	Within pipe	End of pipe	Sources	Pathways
Institutional BMPs										
Education and outreach	√	√	√	√					F,OI,IUP,ID,HW,BDR	
Volunteer cleanup efforts	√	√	√	√	√				F,OI,IUP,ID,HW	
Recycling	√	√	√	√						
Amnesties	√	√	√	√					OI,IUP,HW	
Product Bans/product replacement	√	√	√	√					F,OI,IUP,HW	
Enforcement			√	√					F,OI,IUP,ID,HW,BDR	
Sweeping		√	√	√	√				A,OI,RF,RD,BDR	RI,VT,FT,W
Washing (streets/footpaths)		√	√	√	√				RD,BDR	RI,VT,FT,W
Illicit waste dumping cleanup					√	√	√	√	OI,ID	RI
Stormwater conveyance maintenance				√		√	√	√	A,OI,ID,RF	RI,VT,FT,W
Treatment BMPs										
Infiltration trench		√	√	√		√			A,OI,RF	RI,VT,FT,W
Infiltration basin		√	√	√		√			A,OI,RF	RI,VT,FT,W
Retention and reuse/irrigation	√	√	√			√		√	A,OI,RF	RI,VT,FT,W
Wet Pond		√	√	√		√			A,OI,RF	RI,VT,FT,W
Constructed wetland		√	√	√		√		√	A,OI,RF	RI,VT,FT,W
Extended detention basin		√	√	√		√		√	A,OI,RF	RI,VT,FT,W
Vegetated swale		√	√	√		√			A,OI,RF	RI,VT,FT,W
Vegetated buffer strip		√	√	√		√			A,OI,RF	RI,VT,FT,W
Bioretention (rain garden/green roof)	√	√	√	√		√			A,OI,RF	RI,VT,FT,W
Media filter		√	√	√			√		A,OI,RF	RI,VT,FT,W
Water quality inlet		√	√	√			√		A,OI,RF	RI,VT,FT,W
Wet vault		√	√	√			√		A,OI,RF	RI,VT,FT,W
Hydrodynamic separation		√	√	√			√		A,OI,RF	RI,VT,FT,W
Drain insert		√	√	√			√		A,OI,RF	RI,VT,FT,W
Flow diversion to wastewater treatment								√	All sources	All pathways

True sources: Factories = F, Atmospheric deposition= A
Source areas: Old industrial - OI, PCBs and Hg products still in use = IUP, Illegal disposal - ID, Recycling facilities = RF, Road deposits = RD, Home and work place = HW
Building demolition and remodeling = BDR
Transport pathways: Runoff from impervious surfaces = RL, Vehicle tracking = VT, Foot tracking = FT, Wind = W

Table 7-2. Program Assessment Effectiveness for BMPs (Source: SFEI 2010)

Best management practice (BMP) category	Most applicable effectiveness assessment outcome levels					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	Documenting activities	Raising awareness	Changing behavior	Reducing loads from sources	Improving runoff quality	Protecting receiving water quality
Institutional BMPs						
Education and outreach	√	√	√			
Volunteer cleanup efforts	√			√		
Recycling	√			√		
Amnesties	√			√		
Product Bans / product replacement	√			√		
Enforcement	√	√	√	√		
Sweeping	√			√		
Washing (streets/footpaths)	√			√		
Illicit waste dumping cleanup	√			√		
Stormwater conveyance maintenance	√			√	√	
Treatment BMPs						
Infiltration trench	√			√	√	
Infiltration basin	√			√	√	
Retention and reuse / irrigation	√			√	√	
Wet Pond	√			√		
Constructed wetland	√			√		
Extended detention basin	√			√		
Vegetated swale	√			√	√	
Vegetated buffer strip	√			√	√	
Bioretention (Rain garden / green roof)	√			√	√	
Media filter	√			√		
Water quality inlet	√			√		
Wet vault	√			√		
Hydrodynamic separation	√			√		
Drain insert	√			√		
Flow diversion to wastewater treatment	√			√	√	√

7.3 Funding Opportunities

The most likely funding sources to implement the BMPs described previously are the Great Lakes Restoration Initiative, GLRI (http://greatlakesrestoration.us/index.html), the Illinois Green Infrastructure Program for Stormwater Management (http://www.epa.illinois.gov/topics/grants-loans/water-financial-assistance/igig/index), and Nonpoint Source Section 319 grants (http://www.epa.illinois.gov/topics/water-quality/watershed-management/nonpoint-sources/index). However, multiple other programs can aid in funding measures to reduce PCBs, as shown in Table 7-33.

Table 7-3. Funding Opportunities for Implementation of BMPs and Other Measures for Reducing PCBs

Funding Opportunity	Description
U.S. Environmental Protection Agency	
Great Lakes Restoration Initiative	Funds various projects, including a program area focused on Areas of Concern like Waukegan Harbor.
National Oceanic and Atmospheric Administration	
Coastal Services Center Cooperative Agreements	Provides technical assistance and project grants through a range of programs and partnering agreements, all focused on protecting and improving coastal environments.
Illinois Environmental Protection Agency	
Illinois Green Infrastructure Program for Stormwater Management	Grants are available to local units of government and other organizations to implement green infrastructure BMPs to control stormwater runoff for water quality protection in Illinois. Projects must be located within a MS4 or CSO area. Funds are limited to implementation.
Nonpoint Source Section 319 Grants	Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address issues relating to nonpoint source pollution (like stormwater runoff). Funds can be used for the implementation of watershed management plans, which focus on the installation of BMPs.
Priority Lake and Watershed Implementation Program	Funds implementation of protection/restoration practices that improve water quality, mostly on small, publicly accessible lakes.

7.4 Reasonable Assurance

TMDLs that call for reduction in sources for which an NPDES permit is not required should provide a reasonable assurance that the controls will be implemented and maintained. IEPA believes that a refocusing of existing activities such as stormwater management, and identifying and addressing potential PCB hot spots in the study area, will reduce overall PCB loads in the environment. Removing PCBs that cycle between the atmosphere, water, soil, and sediments, will also reduce loadings to impaired waters, and reduce concentrations in fish to meet the targets of this TMDL.

This section provides reasonable assurances that BMPs will be implemented, along with a description of other projects currently underway that will assist in reducing PCB loads to nearshore Lake Michigan waters.

7.4.1 BMP Implementation

IEPA proposes to work in collaboration with others to reduce the number of potential PCB sources to Lake Michigan. These sources and methods to address them, mainly through the implementation of BMPs are listed below, and are adapted from Washington Department of Ecology (2014).

1. In partnership with communities and stakeholders in the study area, assess schools and other public buildings for the presence of PCB-containing building materials. Identify buildings most likely to contain PCBs based on age, type of construction and scope of any past remodeling.

    a. Survey and assess PCB-containing lamp ballasts in schools and other public buildings. Encourage replacement with more energy efficient PCB –free fixtures. Use data from item 1 above to identify those buildings where PCB-containing light ballasts are likely still in use, with schools as a priority. Lamp ballasts with PCBs can then be identified through visual inspection. Combine PCB removal with increasing energy efficiency where possible.
    b. Find avenues to provide information to government building managers about the importance of removing ballasts and programs aimed at replacing fixtures with more energy efficient fixtures. Provide technical and informational reports for proper handling of PCB containing fixtures.

2. Identify, develop and promote BMPs for containment of PCB-containing materials in buildings currently in use and those slated for demolition.

    a. Work with USEPA Region 5, IEPA, local governments, the Waukegan Harbor Advisory or other local citizen organizations in the TMDL study area to identify outreach materials developed to prevent PCB exposure from building materials and prevent their release into the environment.
    b. Identify additional audiences for outreach and avenues for informational material distribution.
    c. Create a connection to EPA's Green Demolition Initiative by providing added information on potential for PCB-containing materials in demolitions. Circulate through established channels for green demolition materials to appropriate contractors and businesses engaged in demolition activities in Illinois Nearshore Lake Michigan TMDL area.

3. Learn more about what products contain PCBs and promote the use of processes that don't inadvertently generate PCBs. Unpermitted non-point releases, such as from consumer products, are becoming increasingly important to control to reduce overall PCB delivery.
    a. Start with the USEPA report (1982) identifying 70 manufacturing processes likely to inadvertently generate PCBs, and efforts in the Great Lakes to reduce PCBs. Identify existing information about PCBs in pigments and dyes, which are potential sources of PCBs to the environment. Identify potential audiences in the TMDL area for sharing information to develop alternative purchasing options that don't have potential to release PCBs [Note that a list is being developed by Washington Department of Ecology and Green Chemistry Northwest].
    b. Work with EPA and other government partners to promote alternatives to supplies that contain PCBs and share with partner green purchasing programs.

4. Survey and identify “retirement” dates of electrical equipment that contains more than 2 ppm PCB.
   From 1929 to 1979 the production of PCBs in the US was approximately 1.4 billion lbs (600,000 metric tons), with the largest use for electrical equipment (USEPA, 1994). Federal regulations focus on transformers with more than 500 ppm PCBs. Identify funding to collect and properly dispose of this equipment with concentrated PCBs.

5. Use a best management practices approach to reduce PCBs in the study area by effectively managing discharges of PCBs from NPDES permitted stormwater sources, including MS4s. In the Illinois Lake Michigan Nearshore PCB TMDL, The authority to establish BMP conditions in NPDES permits is provided in 40CFR 122.44 (k). IEPA believes that initiating appropriate Minimum Control Measures in their MS4 permits will achieve reductions in PCBs consistent with the Lake Michigan Nearshore PCB TMDL by preventing and removing PCBs that reach impaired waters via stormwater.
   a. Within 60 days of TMDL approval, mail the approved TMDL to MS4 communities and permittees along with a menu of best management practices for implementation of the TMDL in MS4 permits to permittees**.** The proposed MS4 BMP Menu is contained in Appendix C.

6. Compile a list of materials to use for conducting a public educational campaign. Identify and utilize avenues in cooperation with stakeholders for distributing to the public. Refer to Appendix D for examples of resource information.

7.4.2 Great Lakes Projects and Activities

There have been many efforts established that continue to achieve progress in ensuring that the quality of the Great Lakes is restored and maintained. In May 2004, a Presidential Executive Order was signed recognizing the Great Lakes as a national treasure, calling for the creation of a "Regional Collaboration of National Significance," and a cabinet-level Federal Great Lakes Interagency Task Force.

The Great Lakes Water Quality Agreement, first signed by the United States and Canada in 1972, was recently updated in 2012 to better identify and manage current water quality threats to the Great Lakes. This update included 10 priority areas, called “Annexes,” that describe commitments to specific environmental issues. Three Annexes are relevant to this TMDL’s watershed and PCBs:

- Annex 1 Areas of Concern: Restore beneficial uses at AOCs (e.g., Waukegan Harbor) and ensure implementation of Remedial Action Plans.
- Annex 2 Lake Management: Develop a Lakewide Management Plan for Lake Michigan in 2019.
- Annex 3 Chemicals of Mutual Concern: Reduce anthropogenic release of certain chemicals. In February 2014, PCBs were nominated to the list of chemicals of mutual concern. This Annex commits both countries to continued monitoring of PCBs in the Great Lakes and coordinated efforts to reduce release of PCBs.

The Great Lakes Restoration Initiative represents the largest U.S. investment in the Great Lakes in two decades. A task force of 11 Federal agencies developed a plan to put the President’s initiative into action. The GLRI Action Plan II covers fiscal years 2015 through 2019 and addresses four urgent focus areas. One of these focus areas is cleaning up of AOCs, including Waukegan Harbor. PCBs have been a major contaminant of concern in the Waukegan area (Figure 7-1).

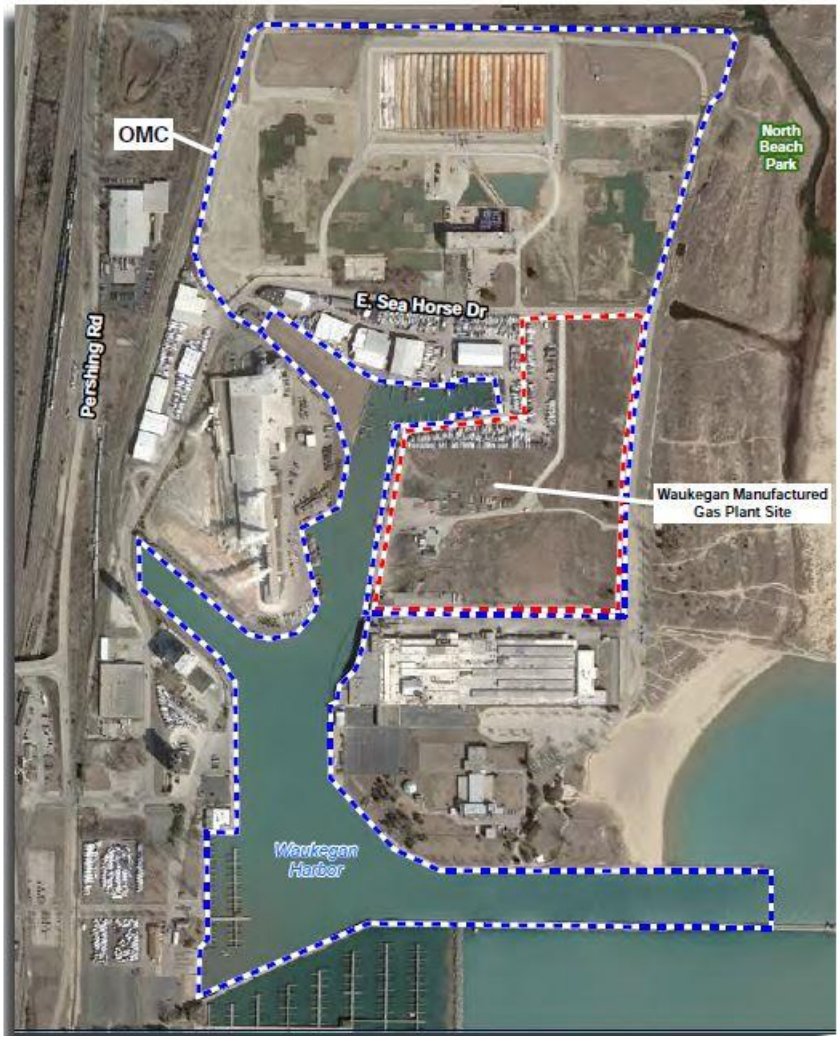

Figure 7-1. Waukegan Harbor AOC

7.4.3 Waukegan Harbor Area of Concern

The Waukegan Harbor AOC/Outboard Motor Company (OMC) Superfund site consists of four cleanup units: Waukegan Harbor, the former Waukegan Manufactured Gas and Coke Plant (WCP), PCB-containment cells and OMC Plant 2. A summary of the contamination at the site and the cleanup process to date is described by USEPA (2014):

> The area was contaminated by PCBs "which OMC used in hydraulic fluids at its boat motor manufacturing plant, and trichloroethylene (TCE), a chlorinated solvent that OMC used to degrease newly-made parts. PCBs are found in Waukegan Harbor and on the OMC Plant 2 site. TCE is found in the groundwater under the OMC Plant 2 site. The WCP portion of the site has a different set of contaminants of concern because OMC did no manufacturing there. Contaminants identified at the WCP site included tars, creosote, arsenic, ammonia, and phenol found in soil and/or groundwater.

> OMC first cleaned up Waukegan Harbor in 1992 by dredging PCB-contaminated sediment. However, EPA determined in 2009 that more dredging was needed to remove residual PCB contamination to fully clean the harbor. In July 2013, EPA completed hydraulic dredging of sediment with residual contamination from the harbor and pumped it to the OMC Plant 2 property for storage in a consolidation facility.
>
> The three PCB containment cells were constructed and filled in 1992. The City of Waukegan, under U.S. EPA oversight, is now in charge of their operation and maintenance. Since 2005, the city has been maintaining the surface covers on the containment cells, conducting routine inspections, and operating the ground-water pumps to remove and then treat water from inside the cells".

The USEPA describes the cleanup of Waukegan Harbor as one of the most significant accomplishments of the Federal Superfund program. The cleanup goal of 50 ppm PCBs in sediment was achieved, followed by lowering the goal to less than 1 ppm. However, until the goal of 1 ppm can be met, the site will remain an AOC (IDNR 2011). The site's status as both an AOC and Superfund site guarantees regulatory action and funding, thus there is reasonable assurance that work will continue to ensure that PCB concentrations in the harbor will decline to a level that is no longer harmful to the environment.

7.5 Monitoring Recommendations to Track TMDL Effectiveness

Post-TMDL monitoring consists of collecting/compiling and analyzing data to evaluate progress toward attaining the TMDL target. Post-TMDL monitoring can assist in determining whether planned control actions are sufficient, or whether further measures need to be implemented. This section describes recommended PCB monitoring for tracking trends and assessing TMDL effectiveness.

7.5.1 Illinois Monitoring

IEPA monitoring is described in IEPA (2014a). Within the Great Lakes Basin, Illinois monitors fish tissue PCB on an annual basis as part of its Fish Contaminant Monitoring Program (FCMP). Results are used to assess the status of existing fish consumption advisories or issue new advisories. Currently, there are advisories for 10 species of fish in Lake Michigan due to elevated PCB concentrations, and four additional species have advisories specific to Waukegan Harbor. Continued monitoring provides important information for the public from a health perspective. Fish tissue PCB concentrations from the FCMP can be used to assess progress toward the TMDL target. These data should be compiled as they become available and assessed to determine if PCB concentrations are decreasing.

7.5.2 Atmospheric Monitoring

The United States and Canada jointly maintain the Great Lakes Integrated Atmospheric Deposition Network (IADN) Program. PCBs are monitored under this program. Atmospheric PCB monitoring at the Chicago site is relevant to this TMDL. PCB concentrations measured at this IADN station can be used to assess atmospheric PCB concentrations over time for the study area and Lake Michigan.

7.6 Schedule

A detailed schedule for implementation of the suggested BMPs is not appropriate in this document. Practical and financial limitations potentially need to be considered and overcome, and communities must be engaged in order to implement the BMPs in this section of the TMDL. However, IEPA intends to engage the public starting with a working meeting to engage partners including the cities in the study area to prioritize the recommended strategies to determine the most feasible options.

NPDES permits must be consistent with the WLA and the assumptions used to derive them. Existing wastewater treatment plants that discharge to Lake Michigan are expected to meet effluent limits that are outlined in their permits. Current NPDES permits will remain in effect until the permits are reissued, provided IEPA receives the NPDES permit renewal application prior to the expiration date of the existing NPDES permit. The WLAs will be incorporated into the permits upon reissuance.

The MS4 communities are covered under the General NPDES Permit No. ILR40 that expired on March 31, 2014. However, General NPDES Permit No. ILR40 is considered to be “administratively continued” until a new General Permit is reissued. The BMPs contained in this Section of the TMDL including the “menu of potential BMPs for MS4s” in Appendix C can be adopted as appropriate, as minimum measures for permits to be consistent with the WLA contained in the TMDL and will be incorporated into the MS4 General Permit by reference. The General Permit will remain in effect until a new General Permit is reissued (pending new Storm Water Regulations).

The current General Permit Part III- Special Condition (C) requires the MS4 Permittee to comply with the WLA when a TMDL is developed for that particular watershed within 18 months of notification by IEPA of the TMDL.

Implementation of the LA is voluntary. However, IEPA believes that the TMDL target will be met based on activities discussed previously in this Section of the TMDL.

8
Public Participation

[This section will be filled in following the public meetings in January 2016]

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9
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Appendix A: 303(d) List of Segments Impaired due to PCBs that are Addressed by this TMDL

Table A-1. PCB-Impaired Segments in the Project Study Area

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	North Point Beach	IL_QH-01	0.42	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	IL Beach State Park North	IL_QH-03	2.72	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Waukegan North Beach	IL_QH-04	1.51	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Waukegan South Beach	IL_QH-05	1.55	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	IL Beach State Park South	IL_QH-09	4.67	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lake Bluff Beach	IL_QI-06	5.5	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lake Forest Beach	IL_QI-10	3.79	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rosewood Beach	IL_QJ	2.19	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Park Ave. Beach	IL_QJ-05	4.08	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Glencoe Beach	IL_QK-04	2.15	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Tower Beach	IL_QK-06	1.17	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lloyd Beach	IL_QK-07	0.32	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Maple Beach	IL_QK-08	0.57	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Elder Beach	IL_QK-09	0.92	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Kenilworth Beach	IL_QL-03	0.76	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Gilson Beach	IL_QL-06	2	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Greenwood Beach	IL_QM-03	0.38	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lee Beach	IL_QM-04	0.43	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lighthouse Beach	IL_QM-05	0.64	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Northwestern University Beach	IL_QM-06	0.73	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Clark Beach	IL_QM-07	0.94	Miles	Fish consumption

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	South Boulevard Beach	IL_QM-08	0.98	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Touhy (Leone) Beach	IL_QN-01	0.41	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Loyola (Greenleaf) Beach	IL_QN-02	0.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Hollywood/ Ostermann Beach	IL_QN-03	0.27	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Foster Beach	IL_QN-04	0.65	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Montrose Beach	IL_QN-05	1.45	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Juneway Terrace	IL_QN-06	0.07	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rogers Beach	IL_QN-07	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Howard Beach	IL_QN-08	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Jarvis Beach	IL_QN-09	0.26	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Pratt Beach	IL_QN-10	0.19	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	North Shore/Columbia	IL_QN-11	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Albion Beach	IL_QN-12	0.53	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Thorndale Beach	IL_QN-13	0.69	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	North Ave. Beach	IL_QO-01	0.55	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Fullerton Beach	IL_QO-02	3.07	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Webster Beach	IL_QO-03	0.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Armitage Beach	IL_QO-04	0.27	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Schiller Beach	IL_QO-05	0.57	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Oak St. Beach	IL_QP-02	0.64	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Ohio St. Beach	IL_QP-03	0.93	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	12th St. Beach	IL_QQ-01	1.93	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	31st St. Beach	IL_QQ-02	3.32	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	49th St. Beach	IL_QR-01	1.43	Miles	Fish consumption

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	Jackson Park/63rd Beach	IL_QS-02	0.73	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rainbow	IL_QS-03	3.34	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	57th St. Beach	IL_QS-04	0.33	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	67th St. Beach	IL_QS-05	0.71	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	South Shore Beach	IL_QS-06	0.43	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Calumet Beach	IL_QT-03	1.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Open Water	Open waters Lake Michigan Nearshore	IL_QLM-01	180	Square miles	Fish consumption
North Point Marina Harbor	North Point Marina Harbor	North Point Marina Harbor	IL_QH	0.121	Square miles	Fish consumption
Waukegan Harbor	Waukegan Harbor	Waukegan Harbor North	IL_QZO	0.0652	Square miles	Fish consumption, Aquatic life
Calumet Harbor	Calumet Harbor	Calumet Harbor	IL_3S	2.4	Square miles	Fish consumption
Diversey Harbor	Diversey Harbor	Diversey Harbor	IL_QZI	0.0456 3	Square miles	Fish consumption

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Appendix B: Historic PCB Uses and Sources

USEPA (1994) compiled historic uses of PCBs in the U.S. (Table B-1) and examples of how these products were used in industrial processes (Table B-2). Specific Aroclor mixtures were created and targeted to specific applications (Table B-3). This information is useful in source identification since Aroclors in sediment/soil, fish and water samples can be distinguished in laboratory analysis and matched with those industries/uses present in the watershed. In addition to Aroclors, there are dozens of other trade names that have been used to refer to PCBs and PCB mixtures. Appendix B of Washington Department of Ecology (2014) has a full list. USEPA has a database of transformers reported to be still in use and that contain PCBs. There were 134 registered transformers that remained in the watershed as of 2011, containing 182,064 kg of PCBs (Table B-4; USEPA, 2011a).

Table B-1. Historic Uses of PCBs in the U.S., 1929-1975 Source: USEPA 1994

PCB Use	Pounds (millions)	Percentage of Total
Capacitors	630	50.3%
Transformers	335	26.7%
Plasticizer Uses	115	9.2%
Hydraulics and Lubricants	80	6.4%
Carbonless Copy Paper	45	3.6%
Heat Transfer Fluids	20	1.6%
Petroleum Additives	1	0.1%
Miscellaneous Industrial Uses	27	2.2%
Totals	1,253	100%

Table B-2. Examples of Legacy Uses of PCBs in Industrial Processes Source: USEPA 1994

Class	US Con-sumption	Examples
Closed: PCB-containing fluid is encased in equipment	75%	Industrial scale transformers, capacitors, voltage regulators
		Fluorescent light ballasts
		Consumer electrical items (fridges, televisions, washing machines)
		Manufacturing machinery (capacitors, transformers, associated switchgear)
Partially closed: PCB-containing fluid potentially has exposure to the outside	10%	Hydraulic fluids
		Heat exchange fluids
		Gas pipelines
Open: PCBs exist in materials that are exposed all the time	15%	Plasticizer in paints, resins, synthetic rubber, surface coatings, wax
		Sealants, waterproofing compound, glues and adhesives
		Caulking compounds
		Pesticide extenders
		Pigments and dyes
		Carbonless copy paper
		Microscope immersion oil
		Sound proofing materials
		Window glazing

Table B-3. End Uses for Specific Aroclor Mixtures Source: ATSDR, 2000

End use	Aroclor								
	1016	1221	1232	1242	1248	1254	1260	1262	1268
Capacitors	•	•				•			
Transformers				•		•	•		
Heat transfer				•					
Hydraulics/lubricants									
Hydraulic fluids			•	•	•	•	•		
Vacuum pumps					•	•			
Gas-transmission turbines		•		•					
Plasticizers:									
Rubbers		•	•	•	•	•			•
Synthetic resins					•	•	•	•	•
Carbonless paper				•					
Miscellaneous:									
Adhesives		•	•	•	•	•			
Wax extenders				•		•			•
Dedusting agents						•	•		
Inks						•			
Cutting oils						•			
Pesticide extenders						•			
Sealants and caulking compounds						•			

Table B-4. Registered transformers that remained in the watershed as of 2011 Source: USEPA, 2011a

RECORD ID	COMPANY	CONT_NAME	CONT_PHONE	ASSIGNED TRANS LOCATION ID	TRANSFORMER BOX NUMBER	SITE	TRANS_STR	TRANS_CITY	TRANS_STATE	TRANS_ZIP	NO_TRANSFORMERS	WT_KG	NAME_OFF	TITLE_OFF	DATE_SIGNED
55	Acme Steel Company	David Holmberg	708-841-8383 ext. 2438	1772	2	Chicago Coke Plant	11236 South Torrence Avenu	Chicago	IL	60617	2	3362	David Holmberg	Manager, Environmental Services	3-Dec-98
56	Acme Steel Company	David Holmberg	708-841-8383 ext. 2438	1773	3	Chicago Furnace Plant	10730 South Burley Avenue	Chicago	IL	60617	3	4182	David Holmberg	Manager, Environmental Services	3-Dec-98
779	Chicago Specialities, Inc.	Cindy Ferguson	773-660-4016	1778	1	Blank	735 East 115th Street	Chicago	IL	60628	2	2931	Robert Fournier	Plant Manager	17-Dec-98
873	ComEd	David Rubner	312-394-4455	1775	2	ComEd Substation Calumet Peaking Unit	3200 East 100th Street	Chicago	IL	60623	17	1455	Brian M McCann	Land Quality Supervisor	1-Dec-98
877	ComEd	David Rubner	312-394-4455	2756	15	ComEd Substation SS-674/ Irving Park	4664 West Irving Park	Chicago	IL	Blank	2	402	Brian McConn	Land Quality Supervisor	1-Dec-98
878	ComEd	David Rubner	312-394-4455	2757	14	ComEd Substation SS-679/Besley Court	1814 North Elston	Chicago	IL	Blank	1	2409	Brian McConn	Land Quality Supervisor	1-Dec-98
879	ComEd	David Rubner	312-394-4455	2758	13	ComEd Substation SS-68/Ardmore	1128 West Ardmore	Chicago	IL	Blank	1	207	Brian McConn	Land Quality Supervisor	1-Dec-98
880	ComEd	David Rubner	312-394-4455	2759	18	ComEd Substation SS-687/Nagel	5837 North Nagel	Chicago	IL	Blank	2	468	Brian McConn	Land Quality Supervisor	1-Dec-98
881	ComEd	David Rubner	312-394-4455	2760	7	ComEd Substation SS-767/Division	1510 Division Street	Chicago	IL	Blank	16	42249	Brian McConn	Land Quality Supervisor	1-Dec-98
882	ComEd	David Rubner	312-394-4455	2761	9	ComEd Substation SS-781/56th St	5549 South Lowe	Chicago	IL	Blank	1	4702	Brian McConn	Land Quality Supervisor	1-Dec-98
883	ComEd	David Rubner	312-394-4455	2762	17	ComEd Substation SS-793/ Laramie	909 North Laramie	Chicago	IL	Blank	2	409	Brian McConn	Land Quality Supervisor	1-Dec-98
884	ComEd	David Rubner	312-394-4455	2763	20	ComEd Substation SS-851/Washtenaw	4722 South Washtenaw	Chicago	IL	Blank	1	584	Brian McConn	Land Quality Supervisor	1-Dec-98
885	ComEd	David Rubner	312-394-4455	2764	19	ComEd Substation SS-875/Throop	6909 South Throop	Chicago	IL	Blank	4	808	Brian McConn	Land Quality Supervisor	1-Dec-98
886	ComEd	David Rubner	312-394-4455	2765	10	ComEd Substation SS-884/ Prairie	4716 South Prairie	Chicago	IL	Blank	1	2673	Brian McConn	Land Quality Supervisor	1-Dec-98
887	ComEd	David Rubner	312-394-4455	2766	11	ComEd Substation SS-896/111th St	2501 West 111th Street	Chicago	IL	Blank	2	1089	Brian McConn	Land Quality Supervisor	1-Dec-98
888	ComEd	David Rubner	312-394-4455	2767	12	ComEd Substation TSS-137/Washington Park	6220 South Prairie Street	Chicago	IL	Blank	1	986	Brian McConn	Land Quality Supervisor	1-Dec-98
889	ComEd	David Rubner	312-394-4455	2768	8	ComEd Substation TSS-31/Galewood	2350 North Narragansett	Chicago	IL	Blank	1	4422	Brian McConn	Land Quality Supervisor	1-Dec-98
890	ComEd	David Rubner	312-394-4455	2769	16	ComEd Substation TSS-35/Lakeview	1141 West Diversey	Chicago	IL	Blank	1	188	Brian McConn	Land Quality Supervisor	1-Dec-98
891	ComEd	David Rubner	312-394-4455	2770	21	ComEd Substation TSS-41/Roseland	10801 South Michagan	Chicago	IL	Blank	3	613	Brian McConn	Land Quality Supervisor	1-Dec-98
896	ComEd	David Rubner	312-394-4455	1753	29	Zion Generating Station	101 Shiloh Boulevard	Zion	IL	60099	23	39715	Brian McConn	Land Quality Supervisor	1-Dec-98
1274	Ford Motor Company	Carla Ward	773-646-7472	1779	1	Chicago Assembly Plant	12600 South Torrence Avenu	Chicago	IL	60633	13	24949	R. Griffin Jr.	Plant Manager	7-Dec-98
1481	Holnam Inc.	Joseph P. Lynch	708-458-3458	3364	1	Under Silo's	8001 West 59th Street	Chicago	IL	Blank	1	4264	Joseph Lynch	Manager of Chicago Terminals	15-Dec-98
2069	North Shore Sanitary District	David C. Miller	847-623-6060	2740	1	Clavey Road Substation	Clavey Road	Highland	IL	Blank	5	7112.76	David C. Miller, ARM	Human Resource Manager	4-Oct-99
2070	North Shore Sanitary District	David C. Miller	847-623-6060	2793	3	Waukegan Substation	Dahringer Road	Waukeg	IL	Blank	4	2575.32	David C. Miller, ARM	Human Resource Manager	4-Oct-99
2212	OMC Waukegan	Michael W. Rehor	847-689-7046	1750	1	Blank	90 Sea Horse Drive	Waukeg	IL	60085	23	28589	Terry D. Schneider	Blank	14-Dec-00
4614	ComEd	Linda Alms	630-576-6731	3652	1	Blank	1100 East 55th Street (ESS-Z-	Chicago	IL	Blank	1	720	Ron Bradley	Director EED ESIH	3-Feb-05
5775	Exelon Corporation - ComEd	Lorinda Alms	630-576-6731	3687	2	Blank	100 N. Western Avenue	Chicago	IL	Blank	1		Neena Hemmady	Supervisor EED Environmental Services-West	6-Jan-06
TOTALS FOR WATERSHED											**134**	**182064.1**			

Michael Baker INTERNATIONAL

Appendix C: Menu of BMPs for MS4s and MS4 Communities

In the Illinois Lake Michigan Nearshore PCB TMDL, IEPA is proposing a best management practices approach to controlling and reducing discharges of PCBs. USEPA has proposed this approach to effectively reduce discharges of PCBs from permitted sources, including MS4s. The authority to establish BMP conditions in NPDES permits is provided in 40CFR 122.44 (k).

IEPA proposes the following example language which can be incorporated into MS4 permits, as adapted from Appendix B 3.1 Specific Recommendations for Areas of Permitted MS4s Contributing to Surface Water Discharges to the Spokane River or Little Spokane River.

MS4-1. Evaluate levels of PCBs in stormwater in areas of the MS4 to identify areas more likely to contribute PCBs to surface waters based on any available information.

MS4-2. Evaluate levels of PCBs in solids, at a quantitation level for total PCBs appropriate for identifying these areas using an EPA-approved test method.

MS4-3. Prioritize BMPs that are related to reducing or eliminating PCBs in stormwater in areas of the MS4 more likely to contribute PCBs to surface waters, based on any available information, including but not limited to the following:

- Previous and ongoing PCB monitoring.
  - Includes monitoring for PCBs in sediment traps, catch basins, and in stormwater suspended particulate matter (SSPM) at frequencies and locations adequate to assess and identify sources of PCBs to municipal stormwater.
- Nearby toxics cleanup sites with PCBs as a known contaminant.
- Business inspections and compliance records.

MS4-4. Remove accumulated solids from drain lines (including inlets, catch basins, sumps, conveyance lines, and oil/water separators) in priority areas of the MS4 at least once during the permit cycle.

MS4-5. Work with partners to remove of any identified legacy PCB sources within the MS4 (e.g., PCB-containing sealant) as soon as practicable.

MS4-6. Purchase preferred products with the lowest practicable PCB concentrations for products likely to contain inadvertently generated PCBs that are likely to contact municipal stormwater, including but not limited to the following:

- Hydroseed
- Dust suppressants
- Traffic marking paint
- Deicer

MS4-7. Collaborative efforts are encouraged to comply with PCB source control requirements to achieve reductions sought in the TMDL

MS4-8. The permits should include the following requirements for new development and redevelopment disturbing one acre or more:

- Site design to minimize impervious areas, preserve vegetation, and preserve natural drainage systems.
- On-site stormwater management.

CCMS4-1. The permits should require the following, for construction projects requiring a building permit from the permittee that do **not** require an NPDES permit for construction stormwater:

- During demolition of any structure with at least 10,000 square feet of floor space and built before January 1, 1980, the permittee should require the building permit applicant to implement BMPs to achieve the following:
  - Prevent removed PCB-containing building materials, including paint, caulk, and pre-1980 fluorescent lighting fixtures,[7] from contacting municipal stormwater or otherwise reaching waters of the United States; and
  - Ensure that disposal of such materials is performed in compliance with applicable state, federal, and local laws.

CCMS4-2. The permits should address possible contributions of PCBs to the MS4 from businesses within the areas served by the MS4 as follows:

- The permits should require the establishment and maintenance of a database of inspections and status of compliance with applicable State and federal laws and local ordinance related to PCBs in stormwater, for businesses within the area served by the MS4.
- Based on the information in the database and other available information, the permits should require the permittees to identify businesses that are likely to contribute PCBs to the MS4 and to follow up with such businesses and appropriate regulatory agencies to develop and implement BMPs to reduce contributions of PCBs to the MS4 from such businesses.

[7] http://www.epa.gov/solidwaste/hazard/tsd/pcbs/pubs/ballasts.htm

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Appendix D: Information Resources for Education and Outreach

Recommendations for Distributing Information

(From the Waukegan Community Information Plan, EPA, May 5, 2015)

One of EPA's goals is to make sure that information about the sites gets out to all community members including different ethnic and age groups. But even more important – we want to be able to engage people and get them involved in the cleanup process, so we asked people for their ideas. We received several ideas of events and/or organizations that can help EPA engage with the community. Listed below are some of the organizations and places that were suggested.

Lilac Cottage in Bowen Park

Lake County Forest Preserves

Leave No Child Inside meetings

Park Place

Schools

Churches

Online calendar of events

Quarterly magazine

Scoop the Loop

Dandelion Wine Fine Arts Festival

Art Walks

Monarch Festival

Waukegan Sports Park

WaukeganMainStreet.org

Black Chamber of Commerce of Lake County

Minister's Alliance

Polar Bear Plunge

4th of July parade

Tour of homes

Library calendar of events

Belvidere Mall

Illinois Refugee Rights (ISIRR.org)